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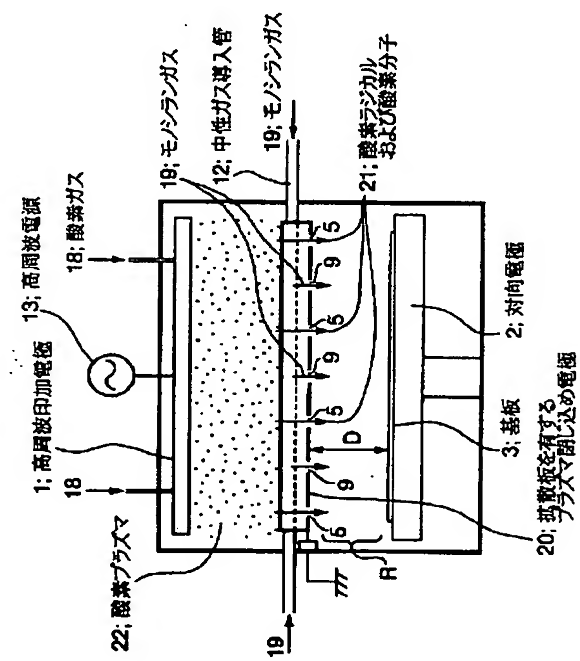
(54)【発明の名称】　プラズマＣＶＤ装置およびプラズマＣＶＤ成膜法

(57)【要約】
【課題】　気相化学反応を用いて成膜を行うリモートプラズマＣＶＤにおいて、気相化学反応の過剰進行抑制と均一膜形成を両立させる。提供する。
【解決手段】　酸素ガス１８を高周波印加電極１に供給し、酸素ラジカル及び酸素分子２１を、酸素プラズマ２２外の基板処理領域Ｒで導入されるモノシランガス１９と反応させ、基板３表面に成膜を行うリモートプラズマＣＶＤにおいて、モノシランガス１９を基板処理領域Ｒに導入する導入孔が配置されたプラズマ閉じ込め電極２０と、基板３（被堆積基板）の垂直方向の距離が、基板処理領域Ｒにおける成膜時平均自由行程λｇの１５００倍以下となっており、かつ前記プラズマ閉じ込め電極２０は、中空構造であってモノシランガス１９（中性ガ）を板内で均一化するためのガス拡散板（第１のガス拡散板及び第２のガス拡散板）が設けられている。



【特許請求の範囲】

【請求項１】　被堆積基板が設置される基板処理領域と、第１のガスのプラズマを形成するプラズマ生成領域と、前記基板処理領域とプラズマ生成領域とを分離して前記第１のガスのプラズマを閉じ込め、第１のガスの前記プラズマから中性ラジカルを含む第１のガスを通過させる孔が配置されたプラズマ閉じ込め電極板を有するプラズマＣＶＤ装置であって、

前記プラズマ閉じ込め電極板が中空構造であり、内部に第２のガスをこのプラズマ閉じ込め電極板内で均一化するためのガス拡散板が設けられており、前記中性ラジカルを含む第１のガスとの気相化学反応によって前記被堆積基板に所望の膜を形成する第２のガスを、前記基板処理領域に導入する導入孔が前記プラズマ閉じ込め電極板に配置され、

前記プラズマ閉じ込め電極板と前記被堆積基板との垂直方向の距離が、基板処理領域における、前記中性ラジカルと前記第２のガスとの混合ガスの成膜時における平均自由行程λｇの１５００倍以下となっていることを特徴とするプラズマＣＶＤ装置。

【請求項２】　前記ガス拡散板が、プラズマ閉じ込め電極内で互いに平行に位置する複数枚の拡散板であることを特徴とする請求項１記載のプラズマＣＶＤ装置。

【請求項３】　プラズマ生成領域において第１のガスのプラズマを形成する第１の過程と、

前記プラズマ生成領域において前記プラズマをプラズマ閉じ込め電極板により閉じ込める第２の過程と、

プラズマ閉じ込め電極板が、配置された孔を通して、前記プラズマから中性ラジカルを基板処理領域へ通過させる第３の過程と、

前記プラズマ閉じ込め電極板が、内部に設けられた、第２のガスを均一化するガス拡散板により、被堆積基板が設置される基板処理領域へ均一化された第２のガスを供給する第４の過程と、

前記中性ラジカルを含む第１のガスと前記第２のガスとの気相化学反応によって、被堆積基板に所望の膜を形成する第５の過程とを有し、

前記プラズマ閉じ込め電極板と前記被堆積基板との垂直方向の距離が、基板処理領域における成膜時平均自由行程λｇの１５００倍以下となっていることを特徴とするプラズマＣＶＤ成膜方法。

【請求項４】　被堆積基板が設置される基板処理領域と、第１のガスのプラズマを形成するプラズマ生成領域と、前記基板処理領域とプラズマ生成領域とを分離して前記第１のガスのプラズマを閉じ込め、第１のガスの前記プラズマから中性ラジカルを含む第１のガスを通過させる孔が配置されたプラズマ閉じ込め電極板を有するプラズマＣＶＤ装置であって、

前記中性ラジカルを含む第１のガスとの気相化学反応によって、前記被堆積基板に所望の膜を形成する第２のガスを基板処理領域に導入する複数の導入孔が設けられたガス供給板を前記プラズマ閉じ込め電極板と前期被堆積基板との間に有し、

前記ガス供給板は中空構造であって、内部に第２のガスを板内で均一化するためのガス拡散板が設けられており、前記ガス供給板と前記被堆積基板の垂直方向の距離が基板処理領域における成膜時平均自由行程λｇの１５００倍以下となっていることを特徴とするプラズマＣＶＤ装置。

【請求項５】　前記ガス拡散板が、ガス供給坂内で互いに平行に位置する複数枚の拡散板であることを特徴とする請求項４記載のプラズマＣＶＤ装置。

【請求項６】　プラズマ生成領域において第１のガスのプラズマを形成する第１の過程と、

前記プラズマ生成領域において前記プラズマをプラズマ閉じ込め電極板により閉じ込める第２の過程と、

プラズマ閉じ込め電極板が、配置された孔を通して、前記プラズマから中性ラジカルを含む第１のガスをこのプラズマ閉じ込め電極板とガス供給板との間に供給する第３の過程と、

前記ガス供給板が、配置された複数の導入孔から中性ラジカルを含む第１のガスを基板処理領域へ通過させる第４の過程と、

前記ガス供給板が、内部に設けられた、第２のガスを均一化するガス拡散板により、被堆積基板が設置される基板処理領域へ均一化された第２のガスを供給する第５の過程と、

前記中性ラジカルを含む第１のガスと前記第２のガスとの気相化学反応によって、被堆積基板に所望の膜を形成する第６の過程とを有し、

前記ガス供給板と前記被堆積基板との垂直方向の距離が、基板処理領域における成膜時平均自由行程λｇの１５００倍以下となっていることを特徴とするプラズマＣＶＤ成膜方法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、プラズマＣＶＤ装置およびこれを用いたプラズマＣＶＤ方法に関し、特に、プラズマ生成領域と基板処理領域とを分離するリモートプラズマＣＶＤ装置、およびリモートプラズマＣＶＤによる大面積均一に緻密な膜の形成方法に係わるものである。

【０００２】

【従来の技術】プラズマダメージを抑制しながら基板への膜形成を行うプラズマＣＶＤ装置の１つに、プラズマ生成領域と基板処理領域Ｒとを分離するリモートプラズマＣＶＤ装置がある。このリモートプラズマ装置を用いたＣＶＤ膜の形成は、半導体デバイスプロセスにおいて高信頼性デバイスや高性能デバイスを作製するための、薄膜作成の処理プロセスとして、非常に重要な技術とな

っている。

【０００３】大面積フラットパネルディスプレイのスイッチングトランジスタ形成プロセスと駆動回路トランジスタ形成プロセス、および大口径シリコンウエハプロセスなどの大型基板に対応できるリモートプラズマＣＶＤ装置としては、例えば特開平５－２１３９３に開示されているような平行平板リモートプラズマＣＶＤ装置が開示されている。

【０００４】この従来例のリモートプラズマＣＶＤ装置における、平行平板型リモートプラズマＣＶＤ装置は、図７に示すように、従来の平行平板プラズマＣＶＤ装置において基板３の設置される対向電極２と高周波印加電極１との間に、複数の孔が開いたメッシュプレートを用いたプラズマ閉じ込め電極８が設けられている。そして、平行平板型リモートプラズマＣＶＤ装置は、このプラズマ閉じ込め電極８と高周波印加電極１との間でプラズマ６を閉じこめるものである。プラズマ閉じ込め電極８と高周波印加電極１の平行平板間で閉じこめた大面積均一なプラズマ６から、基板処理領域Ｒに中性ラジカル４などのガスを供給するため、基板処理領域Ｒに供給された中性ラジカル４などの基板直上面内分布は大面積均一となり、基板３における薄膜形成処理が大面積基板に対しても均一に行えるという特長を有する。

【０００５】さらに、上述の従来例においては、メッシュプレートの孔、すなわちラジカル４の通過孔５の付近に、中性ガス１０を噴射する中性ガス噴射孔９が設けられており、ラジカル４と中性ガス１０との気相反応を用いるプロセスにおいても、基板３に対する膜の生成処理において大面積均一な処理が可能となっている。

【０００６】すなわち、図７に示す平行平板リモートプラズマＣＶＤ装置により、基板処理領域Ｒにおいて気相化学反応を伴う成膜（薄膜の生成処理）を行う場合には、反応に寄与する第１のガスのプラズマ（プラズマ６）を形成し、このプラズマからプラズマ閉じ込め電極８のラジカル通過孔５を通し、励起された第１のガスのラジカル（ラジカル４）及び励起されていない第１のガスを基板処理領域Ｒに供給し、中性ガス噴射孔９から供給される第２のガスと反応させて、薄膜生成に必要な成膜前駆体を形成する。

【０００７】例えば、モノシラン（SiH_4）と酸素（O_2）との反応による酸化シリコン成膜を行う場合には、第１のガスを酸素とし、第２のガスをモノシランとする。このとき、ラジカル通過孔５及び中性ガス噴射孔９が、プラズマ閉じ込め電極８に多数開口されているため、第２のガス（中性ガス１０）が多数の中性ガス噴射孔９から均一に供給されれば、基板処理領域Ｒにおける上記気相反応は、基板３の直上面内で均一に起こり、基板３の表面に均一な膜を形成することができる。

【０００８】上述してきた理由から、平行平板型リモートプラズマＣＶＤ装置は、大型ガラス基板上に薄膜トランジスタのゲート絶縁膜となる酸化シリコン（SiO_2）膜や窒化シリコン膜（Si_3N_4もしくはSi_xN_y）、同じく大型ガラス基板上に薄膜トランジスタの活性層やゲート電極となる非晶質シリコン膜、さらに大型Ｓｉ基板上にトランジスタ素子の層間絶縁膜となる酸化シリコン膜や窒化シリコン膜などを成膜する方法として有望視されている。

【０００９】

【発明が解決しようとする課題】上述したようにラジカル通過孔５の付近に中性ガス噴射孔９を設けて、中性ガス噴射孔９から面内均一な中性ガス１０の供給を行おうとすると、上述した従来例（特開平５－２１３９３）に開示されているように、中空構造のプラズマ閉じ込め電極８を用いることになる。この中空構造のプラズマ閉じ込め電極８においては、図８の閉じ込め電極側面図および図９の閉じ込め電極上面図に示すようにラジカル通過孔５と中性ガス通過孔９とが各々独立に（分離されて）設けられており、中空領域内でラジカル４と中性ガス１０とが混ざり、中空領域内でラジカル４と中性ガス１０とが反応することはない。

【００１０】ここで中空構造のプラズマ閉じ込め電極８に真空チャンバ外部から中性ガス１０を供給する方法として、従来例において開示されているのは、図９または図１０に示すように、プラズマ閉じ込め電極８側面部に設けられた中性ガス導入管１２から、中性ガス１０をプラズマ閉じ込め電極８の中空領域内に供給する方法である。

【００１１】この従来例の方法では、プラズマ閉じ込め電極８における中空部内の圧力が基板処理領域Ｒの成膜圧力と同程度、すなわち数十ｍＴｏｒｒ～数百ｍＴｏｒｒと低圧である。このため図１１の概念図に模式的に示すように、中性ガス導入管１２とプラズマ閉じ込め電極８との接続部付近の中性ガス噴射孔９から大部分の中性ガス１０が噴射されてしまい、中性ガス導入管１２から遠い噴射孔９からは少量の中性ガス１０しか噴射されくなるので、基板３の表面に面内均一な中性ガス１０の噴射が困難となってしまうという欠点がある。

【００１２】このように、表面への面内均一な中性ガス１０の噴射が困難な状況において、基板３表面に面内均一な膜を形成するためには、中性ガス１０を噴射するプラズマ閉じ込め電極８と基板３との距離Ｄを長くすればよい。すなわち、第２のガス（中性ガス１０）が面内不均一に基板処理領域Ｒに供給され、第１のガスと気相化学反応を起こすと、第２のガスが供給された付近では、気相化学反応の結果生成された反応生成物（成膜前駆体）の基板３直上面内分布も不均一となる。

【００１３】しかしながら、上記距離Ｄが長ければ、第２のガスおよび反応生成物が基板３まで移動する間に、基板３表面に対して平行な方向へ拡散する時間が十分与えられるので、基板３表面に到達する時点では、基板３

表面における面内分布が均一化する。この成膜方法においては、ＣＶＤチャンバの幅Wに対して、プラズマ閉じ込め電極８と基板３との距離Ｄが大きいと均一化作用を得やすくなる。

【００１４】例えば、５００mm×６００mmのガラス基板に成膜を行う場合には、ＣＶＤチャンバの幅Wは、８００mm程度になり、プラズマ閉じ込め電極と基板との距離Ｄ１３を同じ長さの８００mm程度にすると十分に均一化作用が現れる。しかしながら気相化学反応による成膜においては、上述のように中性ガス１０を噴射する噴射孔９の設けられたプラズマ閉じ込め電極８と、被堆積基板（基板３）との距離Ｄを長くしてしまうと、中性ラジカルを含む第１のガスと第２のガスとの気相反応が過剰に進み、基板処理領域Ｒにおける気相中で、粒（成膜前駆体）成長が進んでしまい、この成長した粒が被堆積基板表面に堆積するため、生成された膜が疎密になりやすいという問題が生じる。

【００１５】例えば、モノシランと酸素の気相化学反応による酸化シリコン成膜を行う場合には、基板処理領域Ｒにおける気相中で、パーティクル状のSiOx粒（成膜前駆体）が成長することになる。上述の様に生成された疎密な膜は欠陥密度が高いため、リーク電流が大きく絶縁耐圧も低くなるため、薄膜トランジスタのゲート絶縁膜などに使用することはできない。

【００１６】本発明は、このような背景の下になされたもので、気相化学反応によるリモートプラズマＣＶＤ方法での成膜において、過剰な気相化学反応による粒成長を起こさずに、被堆積基板上に緻密で面内均一な膜堆積が行える、成膜前駆体を供給することのできるリモートプラズマＣＶＤ装置およびリモートプラズマＣＶＤ成膜法を提供する事にある。

【００１７】

【課題を解決するための手段】上記の目的を達成するため本発明は、第２のガスを基板処理領域に導入する導入孔が配置されたプラズマ閉じ込め電極板と被堆積基板の垂直方向の距離が、基板処理領域における成膜時平均自由行程λｇの１５００倍以下となっており、かつ前記プラズマ閉じ込め電極板は中空構造であって第２のガスを板内で均一化するためのガス拡散板が設けられていることを特徴としている。拡散板によりプラズマ閉じ込め電極板内で第２のガスが均一化されて基板処理領域に導入されるため、基板直上面内での均一な気相化学反応が起こり、かつ第２ガスが基板処理領域に導入されてから基板に到達するまでに起こる様々な素化学反応の回数が制限され、過剰反応による気相での粒成長が問題ないレベルに抑制されるため、被堆積基板上に面内均一で緻密な膜を形成することが出来る。また本発明では、第２のガスを基板処理領域に導入する導入孔が配置されプラズマ閉じ込め電極と被堆積基板の間に位置するガス供給板と被堆積基板の垂直方向の距離が、基板処理領域における

成膜時平均自由行程λｇの１５００倍以下となっており、かつ前記ガス供給板は中空構造であって第２のガスを板内で均一化するためのガス拡散板が設けられていることを特徴としている。拡散板によりガス供給板内で第２のガスが均一化されて基板処理領域に導入されるため、基板直上面内での均一な気相化学反応が起こり、かつ第２ガスが基板処理領域に導入されてから基板に到達するまでに起こる様々な素化学反応の回数が制限され、過剰反応による気相での粒成長が問題ないレベルに抑制されるため、被堆積基板上に面内均一で緻密な膜を形成することが出来る。

【００１８】請求項１記載の発明は、プラズマＣＶＤ装置において、被堆積基板が設置される基板処理領域と、第１のガスのプラズマを形成するプラズマ生成領域と、前記基板処理領域とプラズマ生成領域とを分離して前記第１のガスのプラズマを閉じ込め、第１のガスの前記プラズマから中性ラジカルを含む第１のガスを通過させる孔が配置されたプラズマ閉じ込め電極板を有するプラズマＣＶＤ装置であって、前記プラズマ閉じ込め電極板が中空構造であり、内部に第２のガスをこのプラズマ閉じ込め電極板内で均一化するためのガス拡散板が設けられており、前記中性ラジカルとの気相化学反応によって前記被堆積基板に所望の膜を形成する第２のガスを、前記基板処理領域に導入する導入孔が前記プラズマ閉じ込め電極板に配置され、前記プラズマ閉じ込め電極板と前記被堆積基板との垂直方向の距離が、基板処理領域における成膜時平均自由行程λｇの１５００倍以下となっていることを特徴とする。

【００１９】請求項２記載の発明は、請求項１記載のプラズマＣＶＤ装置において、前記ガス拡散板が、プラズマ閉じ込め電極内で互いに平行に位置する複数枚の拡散板であることを特徴とする。

【００２０】請求項３記載の発明は、プラズマＣＶＤ成膜方法において、プラズマ生成領域において第１のガスのプラズマを形成する第１の過程と、前記プラズマ生成領域において前記プラズマをプラズマ閉じ込め電極板により閉じ込める第２の過程と、プラズマ閉じ込め電極板が、配置された孔を通して、前記プラズマから中性ラジカルを含む第１のガスを基板処理領域へ通過させる第３の過程と、前記プラズマ閉じ込め電極板が、内部に設けられた、第２のガスを均一化するガス拡散板により、被堆積基板が設置される基板処理領域へ均一化された第２のガスを供給する第４の過程と、前記中性ラジカルを含む第１のガスと前記第２のガスとの気相化学反応によって、被堆積基板に所望の膜を形成する第５の過程とを有し、前記プラズマ閉じ込め電極板と前期被堆積基板との垂直方向の距離が、基板処理領域における成膜時平均自由行程λｇの１５００倍以下となっていることを特徴とする。

【００２１】請求項４記載の発明は、プラズマＣＶＤ装

置において、被堆積基板が設置される基板処理領域と、第１のガスのプラズマを形成するプラズマ生成領域と、前記基板処理領域とプラズマ生成領域とを分離して前記第１のガスのプラズマを閉じ込め、第１のガスの前記プラズマから中性ラジカルを含む第１のガスを通過させる孔が配置されたプラズマ閉じ込め電極板を有するプラズマＣＶＤ装置であって、前記中性ラジカルを含む第１のガスとの気相化学反応によって、前記被堆積基板に所望の膜を形成する第２のガスを基板処理領域に導入する複数の導入孔が設けられたガス供給板を前記プラズマ閉じ込め電極板と前記被堆積基板との間に有し、前記ガス供給板は中空構造であって、内部に第２のガスを板内で均一化するためのガス拡散板が設けられており、前記ガス供給板と被堆積基板の垂直方向の距離が基板処理領域における成膜時平均自由行程λｇの１５００倍以下となっていることを特徴とする。

【００２２】請求項５記載の発明は、請求項４記載のプラズマＣＶＤ装置において、前記ガス拡散板が、ガス供給坂内で互いに平行に位置する複数枚の拡散板であることを特徴とする。

【００２３】請求項６記載の発明は、プラズマＣＶＤ成膜方法において、プラズマ生成領域において第１のガスのプラズマを形成する第１の過程と、前記プラズマ生成領域において前記プラズマをプラズマ閉じ込め電極板により閉じ込める第２の過程と、プラズマ閉じ込め電極板が、配置された孔を通して、前記プラズマから中性ラジカルを含む第１のガスをこのプラズマ閉じ込め電極板とガス供給板との間に供給する第３の過程と、前記ガス供給板が、配置された複数の導入孔から中性ラジカルを含む第１のガスを基板処理領域へ通過させる第４の過程と、前記ガス供給板が、内部に設けられた、第２のガスを均一化するガス拡散板により、被堆積基板が設置される基板処理領域へ均一化された第２のガスを供給する第５の過程と、前記中性ラジカルを含む第１のガスと前記第２のガスとの気相化学反応によって、被堆積基板に所望の膜を形成する第６過程とを有し、前記ガス供給板と前記被堆積基板との垂直方向の距離が、基板処理領域における成膜時平均自由行程λｇの１５００倍以下となっていることを特徴とする。

【００２４】

【発明の実施の形態】以下、図面を参照して本発明の実施形態について説明する。図１は本発明の一実施形態によるリモートプラズマＣＶＤ（化学的気相成長）装置の構成の断面を示す概念図である。本発明の一実施形態を酸素／シラン系の平行平板リモートプラズマＣＶＤ装置における酸化シリコン膜形成を例にとり、以下に図を参照して詳細に説明する。従来例と同様な構成については、同一の符号を付し、この構成の説明を省略する。

【００２５】この図において、平行平板リモートプラズマＣＶＤ装置は、基本的には図１に示すように、真空排

気可能な真空チャンバ、高周波電源１３，高周波印加電極１，基板３を支持する対向電極２，中性ラジカルを含むガスを通過（導入）させるラジカル通過孔５及び中性ガス噴射孔５が設けられ、かつ電気的に接地されたプラズマ閉じ込め電極２０を備え、かつ、プラズマ閉じ込め電極２０の側面から中性ガス（例えば、モノシラン１９）を導入する中性ガス導入管１２によって構成されている。

【００２６】また、プラズマ閉じ込め電極２０には、内部にラジカル通過孔及び中性ガス噴射孔を有する拡散板が設けらている。この拡散板を有するプラズマ閉じ込め電極２０の断面概略図を図２に示す。この図において、プラズマ閉じ込め電極上部板２６とプラズマ閉じ込め電極下部板２７とに挟まれた中空部に、モノシランガス（中性ガス）１９を均一に拡散するための複数のガス拡散板、すなわち一実施形態では第１のガス拡散板２３及び第２のガス拡散板２４が設けられて（配置されて）いる。

【００２７】図２においては、プラズマ閉じ込め電極上部板２６と第１のガス拡散板２３との間にモノシランガス１９が供給され、モノシランガス１９が第１のガス拡散板２３の孔９Ａによって均一化され、さらに第２のガス拡散板２４の孔９Ｂによって均一化され、最後にプラズマ閉じ込め電極下部板２７に設けられた中性ガス噴射孔９から、面内均一にモノシランガス１９が基板３に向かって噴射される。

【００２８】ここで、孔９Ａ，孔９Ｂ及び中性ガス噴射孔９と、ラジカル通過孔５とは、酸素ラジカル及び酸素分子２１とモノシランガス１９とが混合されないように、分離されて（独立して）、プラズマ閉じ込め電極２０内において、各々設けられている。上記の分離を行うために、ラジカル通過孔５は、モノシランの存在する領域から隔離する壁で形成された繋がった孔であり、かつプラズマ閉じ込め電極上部板２６とプラズマ閉じ込め電極下部板２７の間を貫通している。なお、図２では第１の拡散板２３と第２の拡散板２４との２枚の拡散板を示しているが、この拡散板は１枚でも２枚以上の複数枚でも何枚でも良い。

【００２９】プラズマ閉じ込め電極上部板２６からプラズマ閉じ込め電極下部板２７の間に貫通されたラジカル通過孔５の開口孔径は、発生させた酸素プラズマ２２を効率よく閉じ込められるように、発生させた酸素プラズマ２２におけるプラズマのデバイ長の２倍以下程度の長さに設定されている。

【００３０】次に、図３は、プラズマ閉じ込め電極上部板２６とプラズマ閉じ込め電極下部板２７の平面図を示したものである。図３（ａ）はプラズマ閉じ込め電極上部板２６の平面図を示し、図３（ｂ）はプラズマ閉じ込め電極下部板２７の平面図を示している。

【００３１】ここで、図３（ａ）において、プラズマ閉

じ込め電極上部板２６には、閉じ込められた酸素プラズマ２２から、中性ラジカルを含むガスを通過させるラジカル通過孔５が所定の間隔に板内で均一に開孔されている。また、図３（ｂ）において、プラズマ閉じ込め電極下部板２７には、閉じ込められた酸素プラズマ２２から、中性ラジカルを含むガスを通過させるラジカル通過孔５が所定の間隔に板内均一に開孔され、このラジカル通過孔５と一致しない位置に、中性ガス噴射孔９が所定の間隔に板内均一に開孔されている。

【００３２】次に、図４は、ガス拡散板（第１のガス拡散板２３及び第２のガス拡散板２４）の平面図を示している。ここで、上記２枚のガス拡散板、第１のガス拡散板２３及び第２のガス拡散板２４は、図２の第１のガス拡散板２３と第２のガス拡散板２４に対応している。

【００３３】図４（ａ）において、第１のガス拡散板２３には、中性ラジカルを含むガスを通過させるラジカル通過孔５が所定の間隔に板内で均一に開孔され、中性ガス通過孔９が、中心付近の所定の領域Ｑの、ラジカル通過孔５と一致しない位置に、均一に開孔されている。また、図４（ｂ）において、第２のガス拡散板２４には、中性ラジカルを含むガスを通過させるラジカル通過孔５が所定の間隔に板内で均一に開孔され、中性ガス通過孔９が、中心付近の所定の領域Ｐの、ラジカル通過孔５と一致しない位置に、均一に開孔されている。

【００３４】ここで、領域Ｐは、第１のガス拡散板２３と第２のガス拡散板２４とを、プラズマ閉じ込め電極２０に設置するときこの２枚の拡散板を重ねた場合、平面視において上記領域Ｑを含み、かつ領域Ｑより広い領域を示す。すなわち、第２のガス拡散板２４において、中性ガス通過孔９が第１のガス拡散板２３での開孔位置と同様の位置に開孔されているだけではなく、さらにその外周領域にも中性ガス通過孔９が開孔されている。

【００３５】拡散板内全面において、均一に中性ガス通過の孔を開口してもよいが、上述したように、図４に示すように複数の重ねられる拡散板の孔の位置を工夫することにより、図１１に示すように中性ガス導入管１２付近で大量のガスが基板処理領域Ｒに噴射されてしまうのを防ぐことができ、基板３の表面に対して、より面内均一な中性ガス（例えばモノシランガス１９等）の供給を行うことができる。

【００３６】また、拡散板の構成において、第１のガス拡散板２３と第２のガス拡散板２４とを、プラズマ閉じ込め電極２０に設置するときこの２枚の拡散板を重ねた場合、複数の拡散板同士のモノシランガス（中性ガス）１９を流す孔、すなわち孔９Ａと孔９Ｂとが、平面視において重ならないように（直線上に位置しないように）設ける構成も可能である。

【００３７】次に、図１，図２，図３および図４を参照して、本発明の一実施形態によるリモートプラズマＣＶＤ装置による、基板３表面への酸化シリコン膜の形成方法について、以下に説明する。真空排気状態にある（所定の圧力となっている）ＣＶＤチャンバ内で、高周波印加電極１に酸素ガス１８を導入し、この酸素ガス１８が高周波印加電極１の下面からプラズマ閉じ込め電極２０の方向に均一に供給され、拡散板（図４に示す第１のガス拡散板２３及び第２の拡散板２４）を有するプラズマ閉じ込め電極２０との間で、高周波電源１３から高周波印加電極１に供給される高周波によりグロー放電を起こさせる。

【００３８】このグロー放電により発生された酸素プラズマ２２は、高周波印加電極１とプラズマ閉じ込め電極２０との間で効率よく閉じこめられる。その結果、例えば、酸素プラズマ２２におけるプラズマ密度が10^{10}ｃm^{-3}程度であるのに対し、プラズマ閉じ込め電極２０と対向電極２（または基板３）との間のプラズマ密度は10^{5}ｃm^{-3}～10^{6}ｃm^{-3}程度となっている。

【００３９】すなわち、酸素プラズマ２２中には、電子，酸素原子イオン，酸素分子イオン，酸素原子ラジカル，酸素分子ラジカル、酸素分子が存在するが、プラズマ外に侵入する電子およびイオンは無視できる程度の量であることを示している。したがって、酸素プラズマ２２外において、すなわち基板処理領域Ｒに噴射されるモノシランガス１９と反応し、酸化シリコン膜成膜に寄与するのは、酸素原子ラジカル，酸素分子ラジカル，および励起されない酸素分子である。

【００４０】そして、酸素ラジカルおよび酸素分子２１は、ラジカル通過孔５を通って基板処理領域Ｒに拡散し、中性ガス噴射孔９から噴射されたモノシランガス１９と気相化学反応を起こす。この気相化学反応により、ＳｉＯｘ、ＳｉＯｘＨｙ、ＳｉＨｙなどの酸化シリコン前駆体（成膜前駆体）が形成され、この形成された酸化シリコン前駆体が基板３表面に堆積されることにより、基板３表面に酸化シリコン膜を形成する。

【００４１】ここでプラズマ閉じ込め電極２０と基板３との距離Ｄ（垂直方向の距離）は、基板処理領域Ｒにおける酸素（酸素ラジカルおよび酸素分子２１）／モノシラン混合ガスの平均自由工程λｇの１５００倍以下（ただし、「０」を超える数）になるよう設定されている。この距離Ｄにより、気相化学反応が、過剰に進むのを抑制しているため、ＳｉＯｘ、ＳｉＯｘＨｙ、ＳｉＨｙなどの酸化シリコン膜前駆体が、基板処理領域Ｒにおける気相で、粒成長することによって、パーティクル状の大きさに成長することがない。

【００４２】例えば、ガス温度３００℃、チャンバ圧力２５０ｍＴｏｒｒにおいて、酸素／モノシラン混合ガスの平均自由工程λｇは約６０μｍであるため、プラズマ閉じ込め電極と基板との距離Ｄは９０ｍｍ以下とすればよい。実際に、酸化シリコン膜の成膜を行った例として、基板温度３００℃、基板処理領域Ｒ圧力２５０ｍＴｏｒｒ、高周波印加電極１を通してプラズマ領域へ供給

する酸素流量８００ｓｃｃｍ、中性ガス導入管１２へ供給するモノシランガス流量５ｓｃｃｍの条件で成膜した酸化シリコン膜を、ＭＯＳ（金属・酸化膜・半導体）キャパシタのゲート絶縁膜としたときのリーク電流特性を図５に示す。

【００４３】図５において、プラズマ閉じ込め電極２０と基板３との距離Ｄを、３００ｍｍにした場合と、６０ｍｍにした場合とで、リーク電流密度値が大きく変わっている。すなわち、プラズマ閉じ込め電極２０と基板３との距離Ｄを、６０ｍｍとして形成した膜のリーク電流特性は、シリコン熱酸化膜の電流特性に近く、良好であり、薄膜トランジスタのゲート絶縁膜や層間絶縁膜として用いることが可能な電気的絶縁特性及び耐圧を有している。

【００４４】これに対して、プラズマ閉じ込め電極２０と基板３との距離Ｄを、３００ｍｍとして形成した膜のリーク電流特性は、低電界領域から大きなリーク電流が流れており、薄膜トランジスタのゲート絶縁膜や層間絶縁膜には、電気的絶縁特性及び耐圧が低く、用いることができない。

【００４５】上述した実験条件において、基板処理領域Ｒにおける酸素／モノシラン混合ガスの平均自由工程λｇは、約６０μｍである。このとき、電気的絶縁特性及び耐圧が低い方のプラズマ閉じ込め電極２０と基板３との距離Ｄ、すなわち、３００ｍｍは、上記平均自由工程λｇの約５０００倍に相当する。

【００４６】一方、電気的絶縁特性及び耐圧が低い方のプラズマ閉じ込め電極２０と基板３との距離Ｄ、すなわち６０ｍｍは、上記平均自由工程λｇの約１０００倍に相当する。上記平均自由工程λｇの５０００倍もプラズマ閉じ込め電極２０と基板３との距離Ｄが大きいと、酸素ラジカルおよび酸素分子２１と、モノシランガス１９との気相化学反応が進みすぎ、基板処理領域Ｒにおける気相中で粒成長したパーティクルが基板３表面に膜として堆積し、基板３表面に粗密な膜を形成してしまったと推察される。

【００４７】これに対して、上記平均自由工程λｇの１０００倍程度のプラズマ閉じ込め電極２０と基板３との距離Ｄであれば、酸素ラジカルおよび酸素分子２１と、モノシランガス１９との気相化学反応は進みすぎることが無く、気相中での粒成長が制限され、基板３表面においてパーティクル状の酸化シリコン膜前駆体が膜として堆積することはないと推察される。

【００４８】また、上述したように、プラズマ閉じ込め電極２０と対向電極２との間のプラズマ密度は非常に低くなっているために、通常の平行平板プラズマＣＶＤに比べて基板３へのプラズマダメージは非常に低く抑えられている。

【００４９】この効果は、基板３の表面がＭＯＳ界面を形成するシリコン表面の場合には、顕著に現れ、通常の平行平板プラズマＣＶＤで単結晶シリコン基板上にSiO_2膜を形成した場合に、そのＭＯＳ界面準位密度がミッドギャップ付近で10^{11}～$10^{12}cm^{-2}eV^{-1}$であるのに対し、平行平板リモートプラズマＣＶＤで酸化シリコン膜を形成した場合には、～$10^{10}cm^{-2}eV^{-1}$程度の低い界面準位密度となる。

【００５０】以上、本発明の一実施形態を図面を参照して詳述してきたが、具体的な構成はこの実施形態に限られるものではなく、本発明の要旨を逸脱しない範囲の設計変更等があっても本発明に含まれる。例えば、図６を用いて、第２の実施形態による平行平板リモートプラズマＣＶＤを説明する。図６は、平行平板型リモートプラズマＣＶＤ装置の構成の断面を示す概念図である。従来例及び一実施形態と同様な構成については、同一の符号を付し、この構成の説明を省略する。

【００５１】この図において、図６の平行平板型リモートプラズマＣＶＤ装置が、図１の平行平板リモートプラズマＣＶＤ装置と異なるのは、中性ガス導入管１２が接続されて中性ガス（モノシランガス１９）をその中に導入し、内部に設けられたガス拡散板でガス濃度を均一化して基板側へ噴射するガス供給板２９がプラズマ閉じ込めの機能を有しないことである。

【００５２】このため、拡散板を有するガス供給板２９のラジカル通過孔５は、ラジカル４の均一噴射が可能であればその孔径は任意である。また、電気的に接地せずに電気的浮遊状態で使用することも可能である。すなわち、ガス供給板２９は、構成自体は一実施形態におけるプラズマ閉じ込め電極２０と同様であるが、接地されていない点とラジカル通過孔の孔径が異なる。

【００５３】なお、このガス供給板２９は、プラズマ閉じ込め電極８と対向電極２との間に位置しており、ガス供給板２９と基板３との距離Ｆが基板処理領域Ｒにおける酸素（酸素ラジカル及び酸素分子２１）／モノシラン混合ガスの平均自由工程λｇの１５００倍以下（ただし、「０」を超える数）になるよう設定されている。

【００５４】上記以外については、第２の実施形態における、拡散板を有するガス供給板２９と、一実施形態における、拡散板を有するプラズマ閉じ込め電極２０とは、同様の構造を有している。また、ガス供給板２９内のガス拡散板の構造及びガス拡散板の数，ガス拡散板におけるラジカル通過孔及び中性ガスを通過させる孔の分布の関係などに関する考え方は、一実施形態におけるプラズマ閉じ込め電極２０内に設けられるガス拡散板（第１のガス拡散板及び第２のガス拡散板）と同様である。

【００５５】また、ガス供給板２９と基板３との距離Ｆに対する考え方も、一実施形態におけるプラズマ閉じ込め電極２０と基板３との距離Ｄに関する考え方と同様であり、酸素ラジカルおよび酸素分子２１と、モノシランガス１９の気相化学反応が進みすぎることが無く、気相中での粒成長が制限され、パーティクルが膜として基板

３の表面に堆積することはない。

【００５６】以上の一実施形態及び第２の実施形態においては、モノシランと酸素を用いた酸化シリコン膜形成を例にあげて本発明の説明を行ったが、モノシランのかわりにジシランなどの高次シランやＴＥＯＳ（Ｔｅｔｒａｅｔｈｏｘｙｓｉｌａｎｅ）などの液体Ｓｉ原料などでもよく、酸素のかわりに亜酸化窒素、酸化窒素などを用いても良い。

【００５７】また、上述した一実施形態及び第２の実施形態におけるリモートプラズマＣＶＤ装置は、酸化シリコン膜形成を例にあげて説明を行ったが、モノシランとアンモニアとの反応による窒化シリコン膜形成など、他の材料系の気相化学反応を伴うプラズマＣＶＤ成膜に用いても、生成された膜に対して、一実施形態及び第２の実施形態で生成された膜と同様の効果を得ることができる。

【００５８】さらに以上の実施の形態においては、平行平板リモートプラズマＣＶＤ装置を用いた例をあげたが、本発明は、プラズマ生成領域と基板処理領域Ｒとの間に複数の孔が設けられた、プラズマ分離用のプラズマ閉じ込め電極を有するプラズマＣＶＤ装置であれば、マイクロ波プラズマ、電子サイクロトロン共鳴プラズマ、誘導結合プラズマ、ヘリコン波プラズマを用いたプラズマＣＶＤ装置など、どのような形態の装置であっても適用される。

【００５９】

【発明の効果】本発明のリモートプラズマＣＶＤ装置によれば、気相化学反応により成膜を行うリモートプラズマＣＶＤにおいて、気相化学反応の過剰な進行を抑制することができ、かつ、プラズマ領域外で噴射する中性ガスの濃度を、被堆積基板上において均一にすることができる。したがって、本発明のリモートプラズマＣＶＤ装置によれば、ＭＯＳ素子のゲート絶縁膜や層間絶縁膜を作製する際、パーティクルなどを含まない緻密な膜を大面積基板に均一に形成することができる。

【図面の簡単な説明】

【図１】　本発明の第１の実施の形態における平行平板リモートプラズマＣＶＤ装置の側面概略図である。

【図２】　本発明の第１の実施形態における、拡散板を有するプラズマ閉じこめ電極の断面概略図である。

【図３】　本発明の第１の実施の形態における、拡散板を有するプラズマ閉じこめ電極の上部板と下部板の平面概略図である。

【図４】　本発明の第１の実施の形態における拡散板の平面概略図である。

【図５】　堆積した酸化シリコン膜のリーク電流特性を示した図である。

【図６】　本発明の第２の実施の形態における平行平板リモートプラズマＣＶＤ装置の側面概略図である。

【図７】　従来例における平行平板リモートプラズマＣＶＤ装置の側面概略図である。

【図８】　従来例における中空構造のプラズマ閉じ込め電極の断面概略図である。

【図９】　従来例における中空構造のプラズマ閉じ込め電極の平面概略図である。

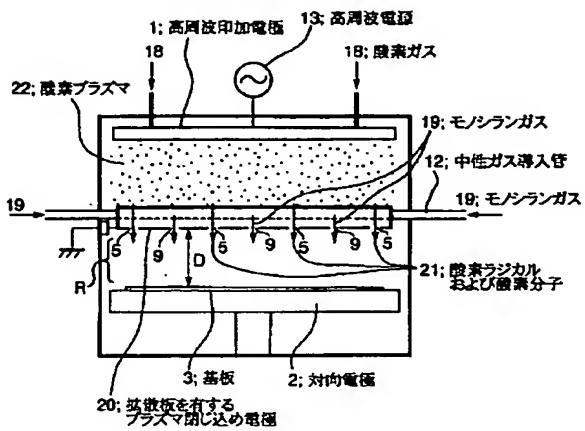
【図１０】　従来例において、中空構造のプラズマ閉じ込め電極に真空チャンバ外部より中性ガスを供給する方法を示した、平行平板リモートプラズマＣＶＤ装置の側面概略図である。

【図１１】　従来例における中空構造のプラズマ閉じ込め電極において、ガスの噴射の様子を示すプラズマ閉じ込め電極の断面概略図である。

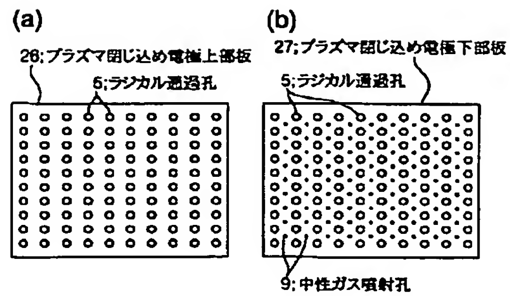
【符号の説明】

１　高周波印加電極
２　対向電極
３　基板
４　ラジカル
５　ラジカル通過孔
６　プラズマ
７　チャンバ壁
８　プラズマ閉じ込め電極
９　中性ガス噴射孔
１０　中性ガス
１１　プラズマ分解用中性ガス
１２　中性ガス導入管
１３　高周波電源
１６　真空排気
１８　酸素ガス
１９　モノシランガス
２０　拡散板を有するプラズマ閉じ込め電極(プラズマ閉じ込め電極)
２１　酸素ラジカルおよび酸素分子
２２　酸素プラズマ
２３　第１のガス拡散板
２４　第２のガス拡散板
２６　プラズマ閉じ込め電極上部板
２７　プラズマ閉じ込め電極下部板
２９　拡散板を有するガス供給板

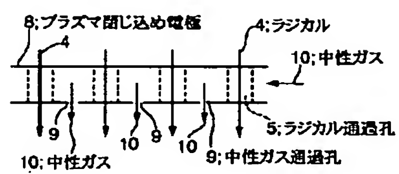
【図１】



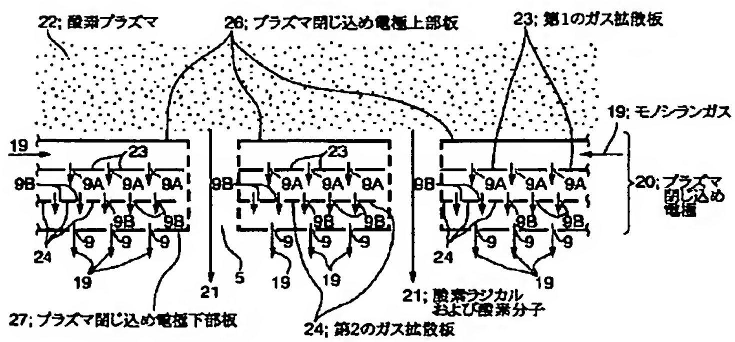
【図３】



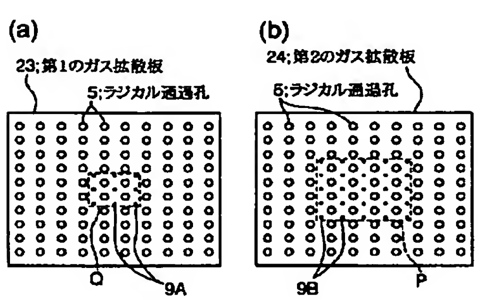
【図８】



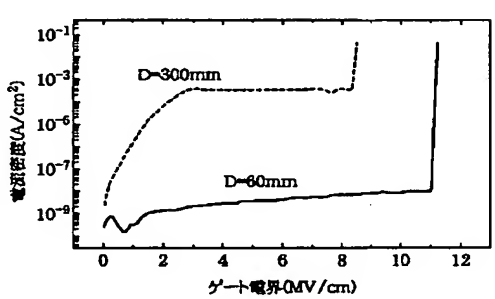
【図２】



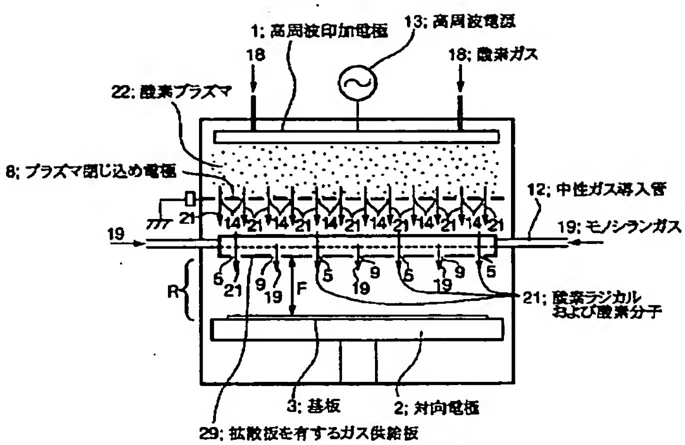
【図４】



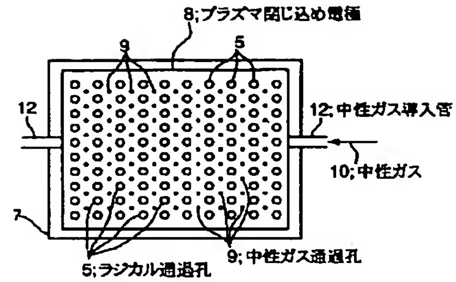
【図５】



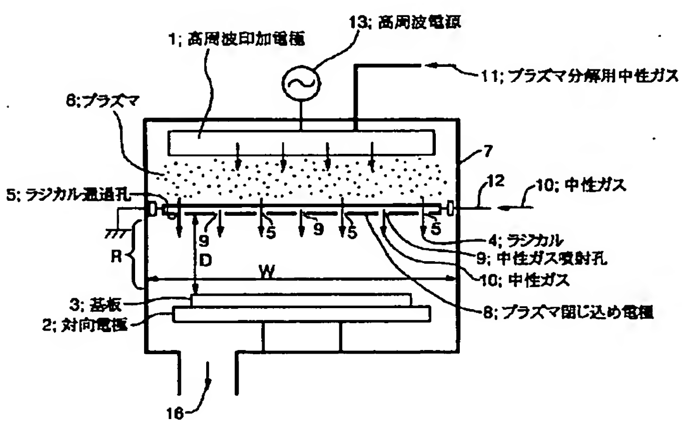
【図６】



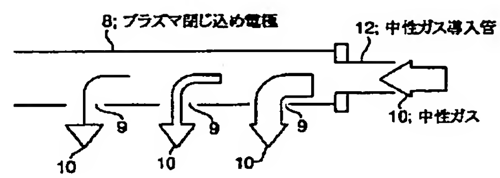
【図９】



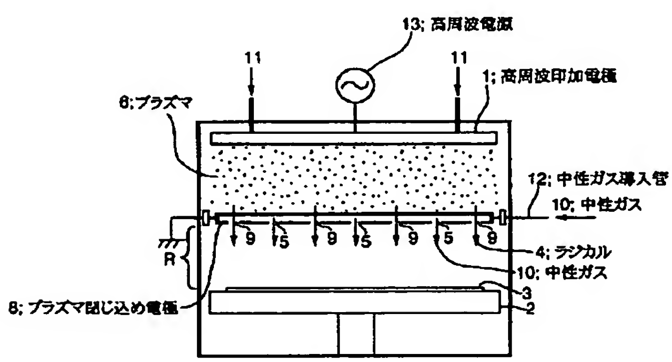
【図７】



【図１１】



【図１０】



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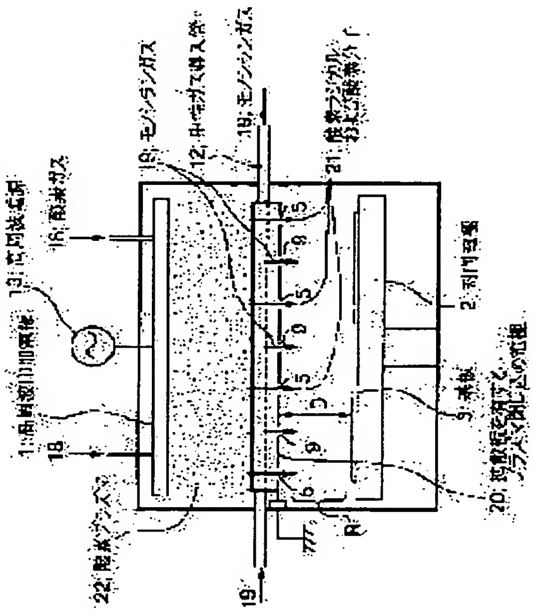
(71)Applicant : NEC CORP
(72)Inventor : YUDA KATSUHISA

(54) PLASMA CVD SYSTEM AND PLASMA CVD FILM DEPOSITION METHOD

(57)Abstract:
PROBLEM TO BE SOLVED: To reconcile the suppression of the surplus progression of vapor phase chemical reaction and uniform film deposition in a remote plasma CVD in which film deposition is executed by using vapor phase chemical reaction.
SOLUTION: In remote plasma CVD in which gaseous oxygen 18 is fed to a high-frequency applying electrode 1, oxygen radicals and oxygen molecules 21 are brought into reaction with gaseous monosilane 19 introduced in a substrate treating region R other than oxygen plasma 22, and the surface of a substrate 3 is deposited with a film, the distance beteen a plasma confining electrode 20 arranged with an introducing port introducing the gaseous monosilane 19 into the substrate treating region R and the vertical direction of the substrate 3 (the substrate to be deposited) is controlled to ≤1500 times the average free path λg at the time of film deposition in the substrate treating region R, and also, the plasma confining electrode 20 is provided with gas diffusion boards each with a hollow structure (a first gas diffusion board and a second gas diffusion board) for uniformizing the gaseous monosilane 19 (neutral gas) in the boards.



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CLAIMS

[Claim(s)]
[Claim 1] The substrate processing field in which a deposited substrate is installed, and the plasma production field which forms the plasma of the 1st gas, Separate said substrate processing field and plasma production field, and the plasma of said 1st gas is shut up. It is plasma-CVD equipment which has the plasma confinement electrode plate with which the hole which passes the 1st gas which contains a neutral radical from said plasma of the 1st gas has been arranged. Said plasma confinement electrode plate is hollow structure, and the gaseous diffusion plate for equalizing the 2nd gas within this plasma confinement electrode plate is formed in the interior. The 2nd gas which forms the desired film in said deposited substrate by the gaseous-phase chemical reaction with the 1st gas containing said neutral radical The introductory hole introduced into said substrate processing field is arranged at said plasma confinement electrode plate. Plasma-CVD equipment characterized by the distance of the perpendicular direction of said plasma confinement electrode plate and said deposited substrate being 1500 or less times of mean free path lambdag at the time of membrane formation of the mixed gas of said neutral radical in a substrate processing field, and said 2nd gas.
[Claim 2] Plasma-CVD equipment according to claim 1 characterized by said gaseous diffusion plates being two or more diffusion plates mutually located in parallel within a plasma confinement electrode.
[Claim 3] The 1st process which forms the plasma of the 1st gas in a plasma production field, The 2nd process which shuts up said plasma with a plasma confinement electrode plate in said plasma production field, The 3rd process in which a plasma confinement electrode plate lets the arranged hole pass, and a neutral radical is passed from said plasma to a substrate processing field, Said plasma confinement electrode plate with the gaseous diffusion plate which was formed in the interior and which equalizes the 2nd gas By the gaseous-phase chemical reaction of the 4th process which supplies the 2nd gas equalized to the substrate processing field in which a deposited substrate is installed, the 1st gas containing said neutral radical, and said 2nd gas The plasma-CVD membrane formation approach characterized by having the 5th process which forms the desired film in a deposited substrate, and the distance of the perpendicular direction of said plasma confinement electrode plate and said deposited substrate having become 1500 or less times of mean free path lambdag at the time of the membrane formation in a substrate processing field.
[Claim 4] The substrate processing field in which a deposited substrate is installed, and the plasma production field which forms the plasma of the 1st gas, Separate said substrate processing field and plasma production field, and the plasma of said 1st gas is shut up. By the gaseous-phase chemical reaction with the 1st gas which is plasma-CVD equipment which has the plasma confinement electrode plate with which the hole which passes the 1st gas which contains a neutral radical from said plasma of the 1st gas has been arranged, and contains said neutral radical It has the gas supply plate with which two or more introductory holes which introduce into a substrate processing field the 2nd gas which forms the desired film in said deposited substrate were prepared between deposited substrates a plasma confinement electrode plate and said first half. Said gas supply plate is hollow structure, and the gaseous diffusion plate for equalizing the 2nd gas within a plate is formed in the interior. Plasma-CVD equipment characterized by the distance of the perpendicular direction of said gas supply plate and said deposited substrate being 1500 or less times of mean free path lambdag at the time of the membrane formation in a substrate processing field.
[Claim 5] Plasma-CVD equipment according to claim 4 characterized by said gaseous diffusion plates being two or more diffusion plates located in parallel mutually in gas supply Sakauchi.
[Claim 6] The 1st process which forms the plasma of the 1st gas in a plasma production field, The 2nd process which shuts up said plasma with a plasma confinement electrode plate in said plasma production field, The 3rd

process which supplies the 1st gas by which a plasma confinement electrode plate lets the arranged hole pass, and contains a neutral radical from said plasma between this plasma confinement electrode plate and a gas supply plate, The 4th process in which the 1st gas by which said gas supply plate contains a neutral radical from two or more arranged introductory holes is passed to a substrate processing field, and said gas supply plate with the gaseous diffusion plate which was formed in the interior and which equalizes the 2nd gas By the gaseous-phase chemical reaction of the 5th process which supplies the 2nd gas equalized to the substrate processing field in which a deposited substrate is installed, the 1st gas containing said neutral radical, and said 2nd gas The plasma-CVD membrane formation approach characterized by having the 6th process which forms the desired film in a deposited substrate, and the distance of the perpendicular direction of said gas supply plate and said deposited substrate having become 1500 or less times of mean free path lambdag at the time of the membrane formation in a substrate processing field.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the formation approach of the film precise to the remote plasma-CVD equipment which separates a plasma production field and a substrate processing field especially, and the large area homogeneity by remote plasma CVD about the plasma-CVD approach which used plasma-CVD equipment and this.
[0002]
[Description of the Prior Art] There is remote plasma-CVD equipment which divides a plasma production field and the substrate processing field R into one of the plasma-CVD equipment which performs film formation to a substrate controlling a plasma damage. Formation of the CVD film using this remote plasma equipment serves as a very important technique as a treatment process of thin film creation for producing a high-reliability device and a high performance device in a semiconductor device process.
[0003] As remote plasma-CVD equipment which can respond to large-sized substrates, such as a switching transistor formation process of a large area flat-panel display, a drive circuit transistor formation process, and a diameter silicon wafer process of macrostomia, parallel monotonous remote plasma-CVD equipment which is indicated by JP,5-21393,A, for example is indicated.
[0004] As the parallel monotonous mold remote plasma-CVD equipment in the remote plasma-CVD equipment of this conventional example is shown in drawing 7 , the plasma confinement electrode 8 using the mesh plate which two or more holes opened is formed between the counterelectrodes 2 and the RF impression electrodes 1 with which a substrate 3 is installed in conventional parallel monotonous plasma-CVD equipment. And parallel monotonous mold remote plasma-CVD equipment shuts up the plasma 6 between this plasma confinement electrode 8 and the RF impression electrode 1. the large area shut up between the plasma confinement electrode 8 and the RF impression electrode 1 parallel being monotonous -- substrate right above side internal division cloth, such as the neutral radical 4 supplied to the substrate processing field R from the uniform plasma 6 in order to supply gas, such as the neutral radical 4, to the substrate processing field R, -- a large area -- it becomes uniform and has the features that the thin film formation processing in a substrate 3 can carry out to homogeneity also to a large area substrate.
[0005] furthermore, generation processing of the film of on the process the inert gas nozzle 9 which injects inert gas 10 is formed near the hole 5 of a mesh plate, i.e., the passage hole of a radical 4, in the above-mentioned conventional example, and using the gaseous phase reaction of a radical 4 and inert gas 10, and as opposed to a substrate 3 -- setting -- a large area -- uniform processing is possible.
[0006] namely, when the parallel monotonous remote plasma-CVD equipment shown in drawing 7 performs membrane formation (generation processing of a thin film) accompanied by a gaseous-phase chemical reaction in the substrate processing field R The plasma (plasma 6) of the 1st gas which contributes to a reaction is formed. The radical passage hole 5 of the plasma confinement electrode 8 from this plasma Through, It is made to react with the 2nd gas which supplies the radical (radical 4) of the 1st excited gas, and the 1st gas which is not excited to the substrate processing field R, and is supplied from the inert gas nozzle 9, and a membrane formation precursor required for thin film generation is formed.
[0007] For example, in performing silicon oxide membrane formation by the reaction of a mono silane (SiH_4) and oxygen (O_2), make the 1st gas into oxygen and let the 2nd gas be a mono silane. Since opening of many radical passage holes 5 and inert gas nozzles 9 is carried out to the plasma confinement electrode 8 at this time, if the 2nd gas (inert gas 10) is supplied to homogeneity from many inert gas nozzles 9, the above-mentioned gaseous

phase reaction in the substrate processing field R occurs in homogeneity in the right above side of a substrate 3, and can form the uniform film in the front face of a substrate 3.
[0008] Since it has mentioned above, promising ** of the parallel monotonous mold remote plasma-CVD equipment is carried out as an approach of forming the silicon oxide (SiO2) film used as the gate dielectric film of a thin film transistor, a silicon nitride film (Si3N4 or SixNy), the amorphous silicone film that similarly serves as a barrier layer of a thin film transistor, and a gate electrode on a large-sized glass substrate, the oxidation silicone film which serves as an interlayer insulation film of a transistor component on a large-sized Si substrate further, a silicon nitride film, etc. on a large-sized glass substrate.
[0009]
[Problem(s) to be Solved by the Invention] When the inert gas nozzle 9 tends to be formed near the radical passage hole 5 as mentioned above, and it is going to supply uniform inert gas 10 in a field from the inert gas nozzle 9, the plasma confinement electrode 8 of hollow structure will be used as indicated by the conventional example (JP,5-21393,A) mentioned above. In the plasma confinement electrode 8 of this hollow structure, as drawing 8 shuts up, an electrode side elevation and drawing 9 shut up and it is shown in an electrode plan, the radical passage hole 5 and the inert gas passage hole 9 are formed independently (dissociating) respectively, a radical 4 and inert gas 10 are mixed in a hollow field, and a radical 4 and inert gas 10 do not react in a hollow field.
[0010] As shown in drawing 9 or drawing 10 , as an approach of supplying inert gas 10, the approach of supplying inert gas 10 in the hollow field of the plasma confinement electrode 8 from the inert gas installation tubing 12 formed in plasma confinement electrode 8 lateral portion is indicated by the plasma confinement electrode 8 of hollow structure in the conventional example here from the vacuum chamber exterior.
[0011] By the approach of this conventional example, the pressures in the centrum in the plasma confinement electrode 8 are the membrane formation pressure of the substrate processing field R, and comparable, i.e., dozens mTorr(s) - hundreds mTorr(s), and low voltage. for this reason, as typically shown in the conceptual diagram of drawing 11 , a great portion of inert gas 10 will be injected from the inert gas nozzle 9 near the connection of the inert gas installation tubing 12 and the plasma confinement electrode 8, and only little inert gas 10 is injected from the nozzle 9 far from the inert gas installation tubing 12 -- having -- ** -- it is ** and the fault that injection of uniform inert gas 10 will be difficult in a field is shown in the front face of a substrate 3.
[0012] Thus, what is necessary is just to lengthen distance D of the plasma confinement electrode 8 and substrate 3 which inject inert gas 10, in order for injection of uniform inert gas 10 to form the uniform film in substrate 3 front face in a field in a difficult situation in the field to a front face. That is, if the 2nd gas (inert gas 10) is supplied to the substrate processing field R at the ununiformity within a field and the 1st gas and gaseous-phase chemical reaction are caused, in the neighborhood to which the 2nd gas was supplied, the substrate 3 right above side internal division cloth of the resultant (membrane formation precursor) generated as a result of the gaseous-phase chemical reaction will also serve as an ununiformity.
[0013] However, since the time amount diffused in the parallel direction to substrate 3 front face will be enough given while the 2nd gas and resultant move even a substrate 3 if the above-mentioned distance D excels, when arriving at substrate 3 front face, the field internal division cloth in substrate 3 front face equalizes. In this membrane formation approach, to the width of face W of a CVD chamber, if the distance D of the plasma confinement electrode 8 and a substrate 3 is large, it will become easy to acquire an equalization operation.
[0014] For example, in forming membranes to a 500mmx600mm glass substrate, the width of face W of a CVD chamber is set to about 800mm, and if distance D13 of a plasma confinement electrode and a substrate is set to about 800mm of the same die length, an equalization operation will fully appear. However, it sets to membrane formation by the gaseous-phase chemical reaction. The plasma confinement electrode 8 with which the nozzle 9 which injects inert gas 10 as mentioned above was formed, If distance D with a deposited substrate (substrate 3) is lengthened, the gaseous phase reaction of the 1st gas and the 2nd gas containing a neutral radical will progress superfluously, and in the gaseous phase in the substrate processing field R the film generated since grain (membrane formation precursor) growth progressed and this grown-up grain accumulated on a deposited substrate front face -- a non-dense -- the problem of being easy to become dense arises.
[0015] For example, when performing silicon oxide membrane formation by the gaseous-phase chemical reaction of a mono silane and oxygen, a particle-like SiOx grain (membrane formation precursor) will grow in the gaseous phase in the substrate processing field R. the non-dense generated as mentioned above -- since defect density is high, it is large and leakage current becomes low also in withstand voltage, the dense film cannot be used for

the gate dielectric film of a thin film transistor etc.
[0016] This invention is to have been made under such a background and offer the remote plasma-CVD equipment and the remote plasma-CVD forming-membranes method for it being precise on a deposited substrate and being able to perform uniform film deposition in a field, without causing the grain growth by the superfluous gaseous-phase chemical reaction, which can supply a membrane formation precursor in membrane formation by the remote plasma-CVD approach by the gaseous-phase chemical reaction.
[0017]
[Means for Solving the Problem] It is characterized by to form the gaseous-diffusion plate for this invention being 1500 or less times of mean free path lambdag at the time of membrane formation [in / in the distance of the perpendicular direction of the plasma confinement electrode plate with which the introductory hole which introduces the 2nd gas into a substrate processing field has been arranged, and a deposited substrate / a substrate processing field], in order to attain the above-mentioned purpose, and said plasma-confinement electrode plate being hollow structure, and equalizing the 2nd gas within a plate. Since the 2nd gas is equalized within a plasma confinement electrode plate with a diffusion plate and it is introduced into a substrate processing field, The count of a chemical reaction is restricted. various base which the uniform gaseous-phase chemical reaction in a substrate right above side occurs, and happens after the 2nd gas is introduced into a substrate processing field before reaching a substrate -- Since the grain growth by the gaseous phase by overresponse is controlled by satisfactory level, the uniform and precise film can be formed in a field on a deposited substrate. Moreover, the distance of the perpendicular direction of the gas supply plate which the introductory hole which introduces the 2nd gas into a substrate processing field is arranged in this invention, and is located between a plasma confinement electrode and a deposited substrate, and a deposited substrate It is characterized by forming the gaseous diffusion plate for being 1500 or less times of mean free path lambdag at the time of the membrane formation in a substrate processing field, and said gas supply plate being hollow structure, and equalizing the 2nd gas within a plate. Since the 2nd gas is equalized within a gas supply plate with a diffusion plate and it is introduced into a substrate processing field, The count of a chemical reaction is restricted. various base which the uniform gaseous-phase chemical reaction in a substrate right above side occurs, and happens after the 2nd gas is introduced into a substrate processing field before reaching a substrate -- Since the grain growth by the gaseous phase by overresponse is controlled by satisfactory level, the uniform and precise film can be formed in a field on a deposited substrate.
[0018] The substrate processing field in which, as for invention according to claim 1, a deposited substrate is installed in plasma-CVD equipment, Separate the plasma production field which forms the plasma of the 1st gas, and said substrate processing field and plasma production field, and the plasma of said 1st gas is shut up. It is plasma-CVD equipment which has the plasma confinement electrode plate with which the hole which passes the 1st gas which contains a neutral radical from said plasma of the 1st gas has been arranged. Said plasma confinement electrode plate is hollow structure, and the gaseous diffusion plate for equalizing the 2nd gas within this plasma confinement electrode plate is formed in the interior. The 2nd gas which forms the desired film in said deposited substrate by the gaseous-phase chemical reaction with said neutral radical The introductory hole introduced into said substrate processing field is arranged at said plasma confinement electrode plate, and it is characterized by the distance of the perpendicular direction of said plasma confinement electrode plate and said deposited substrate being 1500 or less times of mean free path lambdag at the time of the membrane formation in a substrate processing field.
[0019] Invention according to claim 2 is characterized by said gaseous diffusion plates being two or more diffusion plates mutually located in parallel within a plasma confinement electrode in plasma-CVD equipment according to claim 1.
[0020] The 1st process in which invention according to claim 3 forms the plasma of the 1st gas in a plasma production field in the plasma-CVD membrane formation approach, The 2nd process which shuts up said plasma with a plasma confinement electrode plate in said plasma production field, The 3rd process in which the 1st gas by which a plasma confinement electrode plate lets the arranged hole pass, and contains a neutral radical from said plasma is passed to a substrate processing field, Said plasma confinement electrode plate with the gaseous diffusion plate which was formed in the interior and which equalizes the 2nd gas By the gaseous-phase chemical reaction of the 4th process which supplies the 2nd gas equalized to the substrate processing field in which a deposited substrate is installed, the 1st gas containing said neutral radical, and said 2nd gas It has the 5th process which forms the desired film in a deposited substrate, and is characterized by the distance of a perpendicular direction with a deposited substrate being 1500 or less times of mean free path lambdag at the

time of the membrane formation in a substrate processing field a plasma confinement electrode plate and said first half.
[0021] The substrate processing field in which, as for invention according to claim 4, a deposited substrate is installed in plasma-CVD equipment, Separate the plasma production field which forms the plasma of the 1st gas, and said substrate processing field and plasma production field, and the plasma of said 1st gas is shut up. By the gaseous-phase chemical reaction with the 1st gas which is plasma-CVD equipment which has the plasma confinement electrode plate with which the hole which passes the 1st gas which contains a neutral radical from said plasma of the 1st gas has been arranged, and contains said neutral radical It has the gas supply plate with which two or more introductory holes which introduce into a substrate processing field the 2nd gas which forms the desired film in said deposited substrate were prepared between said plasma confinement electrode plate and said deposited substrate. It is characterized by being hollow structure, forming the gaseous diffusion plate for equalizing the 2nd gas within a plate in the interior, and said gas supply plate having become 1500 or less times of mean free path lambdag at the time of membrane formation [in / in the distance of the perpendicular direction of said gas supply plate and a deposited substrate / a substrate processing field].
[0022] Invention according to claim 5 is characterized by said gaseous diffusion plates being two or more diffusion plates located in parallel mutually in gas supply Sakauchi in plasma-CVD equipment according to claim 4.
[0023] The 1st process in which invention according to claim 6 forms the plasma of the 1st gas in a plasma production field in the plasma-CVD membrane formation approach, The 2nd process which shuts up said plasma with a plasma confinement electrode plate in said plasma production field, The 3rd process which supplies the 1st gas by which a plasma confinement electrode plate lets the arranged hole pass, and contains a neutral radical from said plasma between this plasma confinement electrode plate and a gas supply plate, The 4th process in which the 1st gas by which said gas supply plate contains a neutral radical from two or more arranged introductory holes is passed to a substrate processing field, and said gas supply plate with the gaseous diffusion plate which was formed in the interior and which equalizes the 2nd gas By the gaseous-phase chemical reaction of the 5th process which supplies the 2nd gas equalized to the substrate processing field in which a deposited substrate is installed, the 1st gas containing said neutral radical, and said 2nd gas It has the 6th process which forms the desired film in a deposited substrate, and is characterized by the distance of the perpendicular direction of said gas supply plate and said deposited substrate being 1500 or less times of mean free path lambdag at the time of the membrane formation in a substrate processing field.
[0024]
[Embodiment of the Invention] Hereafter, the operation gestalt of this invention is explained with reference to a drawing. Drawing 1 is the conceptual diagram showing the cross section of the configuration of the remote plasma-CVD (chemical vapor growth) equipment by 1 operation gestalt of this invention. Oxidation silicone film formation [in / for 1 operation gestalt of this invention / the parallel monotonous remote plasma-CVD equipment of oxygen / silane system] is taken for an example, and it explains with reference to drawing below at a detail. About the same configuration as the conventional example, the same sign is attached and explanation of this configuration is omitted.
[0025] In this drawing parallel monotonous remote plasma-CVD equipment As fundamentally shown in drawing 1 , the radical passage hole 5 and the inert gas nozzle 5 which pass the vacuum chamber in which evacuation is possible, RF generator 13, the high frequency impression electrode 1, the counterelectrode 2 that supports a substrate 3, and the gas containing a neutral radical (installation) are prepared. And it is constituted by the inert gas installation tubing 12 which is equipped with the plasma confinement electrode 20 grounded electrically, and introduces inert gas (for example, mono silane 19) from the side face of the plasma confinement electrode 20.
[0026] Moreover, the diffusion plate which has a radical passage hole and an inert gas nozzle prepares in the interior at the plasma confinement electrode 20, and it is ********. The cross-section schematic diagram of the plasma confinement electrode 20 which has this diffusion plate is shown in drawing 2 . In this drawing, the 1st gaseous diffusion plate 23 and the 2nd gaseous diffusion plate 24 are formed, and are in the centrum inserted into the plasma confinement electrode up plate 26 and the plasma confinement electrode lower plate 27 (arranged)., two or more gaseous diffusion plates, i.e., 1 operation gestalt, for diffusing mono-silane gas (inert gas) 19 in homogeneity
[0027] In drawing 2 , mono-silane gas 19 is supplied between the plasma confinement electrode up plate 26 and the 1st gaseous diffusion plate 23. Mono-silane gas 19 is equalized by hole 9A of the 1st gaseous diffusion plate 23. Furthermore it is equalized by hole 9B of the 2nd gaseous diffusion plate 24, and mono-silane gas 19 is

injected toward a substrate 3 by the homogeneity within a field from the inert gas nozzle 9 finally prepared in the plasma confinement electrode lower plate 27.
[0028] Here, it dissociates (becoming independent) and hole 9A, hole 9B and the inert gas nozzle 9, and the radical passage hole 5 are respectively formed in the plasma confinement electrode 20 so that an oxygen radical and the oxygen molecule 21, and mono-silane gas 19 may not be mixed. In order to perform the above-mentioned separation, the radical passage hole 5 is a connected hole which was formed with the wall isolated from the field where a mono silane exists, and has penetrated between the plasma confinement electrode up plate 26 and the plasma confinement electrode lower plates 27. In addition, although drawing 2 shows two diffusion plates of the 1st diffusion plate 23 and the 2nd diffusion plate 24, one sheet, two or more two sheets or more, or how many sheets are sufficient as this diffusion plate.
[0029] The opening aperture of the radical passage hole 5 penetrated between the plasma confinement electrode up plate 26 and the plasma confinement electrode lower plate 27 is set as the die length of 2 double less or equal extent of the Debye length of the plasma in the generated oxygen plasma 22 so that the generated oxygen plasma 22 can be shut up efficiently.
[0030] Next, drawing 3 shows the top view of the plasma confinement electrode up plate 26 and the plasma confinement electrode lower plate 27. Drawing 3 (a) shows the top view of the plasma confinement electrode up plate 26, and drawing 3 (b) shows the top view of the plasma confinement electrode lower plate 27.
[0031] Here, in drawing 3 (a), the radical passage hole 5 which passes the gas containing a neutral radical is punctured by predetermined spacing within the plate at homogeneity from the oxygen plasma 22 shut up by the plasma confinement electrode up plate 26. Moreover, in drawing 3 (b), from the oxygen plasma 22 shut up by the plasma confinement electrode lower plate 27, the radical passage hole 5 which passes the gas containing a neutral radical is punctured by predetermined spacing at the homogeneity in a plate, and the inert gas nozzle 9 is punctured by predetermined spacing in the location which is not in agreement with this radical passage hole 5 at the homogeneity in a plate.
[0032] Next, drawing 4 shows the top view of a gaseous diffusion plate (the 1st gaseous diffusion plate 23 and 2nd gaseous diffusion plate 24). Here, two above-mentioned gaseous diffusion plates, the 1st gaseous diffusion plate 23, and the 2nd gaseous diffusion plate 24 are equivalent to the 1st gaseous diffusion plate 23 of drawing 2 , and the 2nd gaseous diffusion plate 24.
[0033] In drawing 4 (a), the radical passage hole 5 which passes the gas which contains a neutral radical in the 1st gaseous diffusion plate 23 is punctured by predetermined spacing within a plate at homogeneity, and the inert gas passage hole 9 is punctured by homogeneity in the location which is not in agreement with the radical passage hole 5 of the predetermined field Q near a core. Moreover, in drawing 4 (b), the radical passage hole 5 which passes the gas which contains a neutral radical in the 2nd gaseous diffusion plate 24 is punctured by predetermined spacing within a plate at homogeneity, and the inert gas passage hole 9 is punctured by homogeneity in the location which is not in agreement with the radical passage hole 5 of the predetermined field P near a core.
[0034] Here, Field P shows a field larger than Field Q in plane view, including the above-mentioned field Q, when installing the 1st gaseous diffusion plate 23 and the 2nd gaseous diffusion plate 24 in the plasma confinement electrode 20 and these two diffusion plates are piled up. That is, the inert gas passage hole 9 is not only punctured by the puncturing location in the 1st gaseous diffusion plate 23, and the same location, but in the 2nd gaseous diffusion plate 24, the inert gas passage hole 9 is further punctured by the periphery field.
[0035] On the whole surface in a diffusion plate, although opening of the hole of inert gas passage may be carried out to homogeneity, as mentioned above By devising the location of the hole of the diffusion plate which plurality piles up as shown in drawing 4 As shown in drawing 11 , it can prevent a lot of gas being injected by the substrate processing field R in the inert gas installation tubing 12 neighborhood, and uniform inert gas (for example, mono-silane gas 19 grade) can be supplied more in a field to the front face of a substrate 3.
[0036] moreover, in the configuration of a diffusion plate, when installing the 1st gaseous diffusion plate 23 and the 2nd gaseous diffusion plate 24 in the plasma confinement electrode 20 and these two diffusion plates are piled up, the configuration which forms the mono-silane gas (inert gas) 19 of two or more diffusion plates so that the hole to pour, i.e., hole 9A, and hole 9B may not lap in plane view (it is not located on a straight line — as) is also possible.
[0037] Next, with reference to drawing 1 , drawing 2 , drawing 3 , and drawing 4 , the formation approach of the oxidation silicone film to substrate 3 front face by the remote plasma-CVD equipment by 1 operation gestalt of this invention is explained below. Within the CVD chamber in an evacuation condition (it has a predetermined

pressure) Introduce oxygen gas 18 into the RF impression electrode 1, and this oxygen gas 18 is supplied in the direction of the plasma confinement electrode 20 from the inferior surface of tongue of the RF impression electrode 1 at homogeneity. Glow discharge is made to start from RF generator 13 by the RF supplied to the RF impression electrode 1 between the plasma confinement electrodes 20 which have a diffusion plate (the 1st gaseous diffusion plate 23 and the 2nd diffusion plate 24 which are shown in drawing 4).
[0038] The oxygen plasma 22 generated by this glow discharge is efficiently shut up between the RF impression electrode 1 and the plasma confinement electrode 20. The plasma consistency between the plasma confinement electrode 20 and a counterelectrode 2 (or substrate 3) has become about [105cm − 3−106cm −] three to the plasma consistency in the result 22, for example, the oxygen plasma, being about [1010cm −] three.
[0039] That is, although an electron, oxygen atom ion, oxygen molecular ion, an oxygen atom radical, an oxygen molecule radical, and an oxygen molecule exist in the oxygen plasma 22, it is shown that the electron and ion which invade out of the plasma are the amount of extent which can be disregarded. Therefore, what it reacts with the mono-silane gas 19 injected by the substrate processing field R besides the oxygen plasma 22, and is contributed to silicon oxide film membrane formation is an oxygen atom radical, an oxygen molecule radical, and an oxygen molecule that is not excited.
[0040] And an oxygen radical and the oxygen molecule 21 are diffused to the substrate processing field R through the radical passage hole 5, and the mono-silane gas 19 and the gaseous-phase chemical reaction which were injected from the inert gas nozzle 9 are caused. Of this gaseous-phase chemical reaction, silicon oxide precursors (membrane formation precursor), such as SiOx, SiOxHy, and SiHy, are formed, and when this formed silicon oxide precursor accumulates on substrate 3 front face, an oxidation silicone film is formed in substrate 3 front face.
[0041] The distance D of the plasma confinement electrode 20 and a substrate 3 (vertical distance) is set up here so that it may become 1500 or less (however, number exceeding "0") times of average free process lambdag of the oxygen (the oxygen radical and oxygen molecule 21) / mono-silane mixed gas in the substrate processing field R. Since it has controlled that a gaseous-phase chemical reaction progresses superfluously with this distance D, when oxidation silicone film precursors, such as SiOx, SiOxHy, and SiHy, carry out grain growth by the gaseous phase in the substrate processing field R, it does not grow up to be particle-like magnitude.
[0042] For example, what is necessary is just to set distance D of a plasma confinement electrode and a substrate to 90mm or less in the gas temperature of 300 degrees C, and chamber pressure 250mTorr, since average free process lambdag of oxygen / mono-silane mixed gas is about 60 micrometers. The leak current characteristic when using as the gate dielectric film of an MOS (metal, oxide-film, and semi-conductor) capacitor the oxidation silicone film which actually formed membranes as an example which formed the oxidation silicone film on condition that the substrate temperature of 300 degrees C, substrate processing field R pressure 250mTorr, oxygen flow rate 800sccm supplied to a plasma field through the RF impression electrode 1, and mono-silane quantity-of-gas-flow 5sccm supplied to the inert gas installation tubing 12 is shown in drawing 5 .
[0043] In drawing 5 , the leak current density value has changed a lot by the case where distance D of the plasma confinement electrode 20 and a substrate 3 is set to 300mm, and the case where it is made 60mm. That is, the leak current characteristic of the film which formed the distance D of the plasma confinement electrode 20 and a substrate 3 as 60mm has near, the electric insulating property [it is good and] which can be used as gate dielectric film and the interlayer insulation film of a thin film transistor, and pressure-proofing in the current characteristic of the silicon thermal oxidation film.
[0044] On the other hand, big leakage current is flowing from the low electric-field field, the leak current characteristic of the film which formed the distance D of the plasma confinement electrode 20 and a substrate 3 as 300mm has an electric insulating property and low pressure-proofing to gate dielectric film and the interlayer insulation film of a thin film transistor, and they cannot use it for them.
[0045] In the experiment conditions mentioned above, average free process lambdag of the oxygen / mono-silane mixed gas in the substrate processing field R is about 60 micrometers. At this time, it corresponds by about 5000 times the above-mentioned average free process lambdag the distance D of an electric insulating property and the plasma confinement electrode 20 with lower pressure-proofing, and a substrate 3, i.e., 300mm.
[0046] On the other hand, it corresponds by about 1000 times the above-mentioned average free process lambdag the distance D of an electric insulating property and the plasma confinement electrode 20 with lower pressure-proofing, and a substrate 3, i.e., 60mm. If the distance D of the plasma confinement electrode 20 and a substrate 3 is 5000 times as large as the above-mentioned average free process lambdag, the gaseous-phase chemical reaction of an oxygen radical and the oxygen molecule 21, and mono-silane gas 19 will progress too

much, the particle which carried out grain growth in the gaseous phase in the substrate processing field R will accumulate on substrate 3 front face as film, and it will be guessed that the roughness and fineness film has been formed in substrate 3 front face.
[0047] On the other hand, if it is the distance D of the about 1000 times [of the above-mentioned average free process lambdag] plasma confinement electrode 20, and a substrate 3, the gaseous-phase chemical reaction of an oxygen radical and the oxygen molecule 21, and mono-silane gas 19 will not progress too much, grain growth in a gaseous phase will be restricted, and it will be guessed that a particle-like oxidation silicone film precursor does not accumulate as film in substrate 3 front face.
[0048] Moreover, as mentioned above, since the plasma consistency between the plasma confinement electrode 20 and a counterelectrode 2 is very low, compared with the usual parallel monotonous plasma CVD, the plasma damage to a substrate 3 is stopped very low.
[0049] To the case on the front face of silicon in which the front face of a substrate 3 forms an MOS interface, this effectiveness When it appears notably and SiO2 film is formed on a single crystal silicon substrate by the usual parallel monotonous plasma CVD When an oxidation silicone film is formed by parallel monotonous remote plasma CVD to the MOS interface-state-density consistency being 1011-1012cm-2eV-1 near a mid gap, it becomes an about [-1010cm-2eV-1] low interface-state-density consistency.
[0050] As mentioned above, although 1 operation gestalt of this invention has been explained in full detail with reference to a drawing, a concrete configuration is not restricted to this operation gestalt, and even if the design change of the range which does not deviate from the summary of this invention etc. occurs, it is included in this invention. For example, the parallel monotonous remote plasma CVD by the 2nd operation gestalt is explained using drawing 6 . Drawing 6 is the conceptual diagram showing the cross section of the configuration of parallel monotonous mold remote plasma-CVD equipment. About the same configuration as the conventional example and 1 operation gestalt, the same sign is attached and explanation of this configuration is omitted.
[0051] In this drawing, the parallel monotonous mold remote plasma-CVD equipment of drawing 6 differing from the parallel monotonous remote plasma-CVD equipment of drawing 1 is that the gas supply plate 29 which the inert gas installation tubing 12 is connected, introduces inert gas (mono-silane gas 19) into it, equalizes gas concentration with the gaseous diffusion plate formed in the interior, and is injected to a substrate side does not have the function of plasma confinement.
[0052] For this reason, that aperture is arbitrary if homogeneity injection of a radical 4 is possible for the radical passage hole 5 of the gas supply plate 29 which has a diffusion plate. Moreover, it is also possible to use it in the state of electric suspension, without grounding electrically. That is, although the gas supply plate 29 of the configuration itself is the same as that of the plasma confinement electrode 20 in 1 operation gestalt, the apertures of the point and radical passage hole which are not grounded differ.
[0053] In addition, this gas supply plate 29 is located between the plasma confinement electrode 8 and a counterelectrode 2, and it is set up so that the distance F of the gas supply plate 29 and a substrate 3 may become 1500 or less (however, number exceeding "0") times of average free process lambdag of the oxygen (the oxygen radical and oxygen molecule 21) / mono-silane mixed gas in the substrate processing field R.
[0054] Except the above, it has the structure where the plasma confinement electrode 20 which has the gas supply plate 29 which has a diffusion plate in the 2nd operation gestalt, and a diffusion plate in 1 operation gestalt is the same. Moreover, the view about the relation of distribution of the hole which passes the radical passage hole and inert gas in the structure of the gaseous diffusion plate in the gas supply plate 29 and the number of gaseous diffusion plates, and a gaseous diffusion plate etc. is the same as that of the gaseous diffusion plate (the 1st gaseous diffusion plate and 2nd gaseous diffusion plate) formed in the plasma confinement electrode 20 in 1 operation gestalt.
[0055] Moreover, it is the same as that of the view about the distance D of the plasma confinement electrode 20 and substrate 3 in 1 operation gestalt, an oxygen radical and the oxygen molecule 21, and the gaseous-phase chemical reaction of mono-silane gas 19 do not progress too much, grain growth in a gaseous phase is restricted, and particle does not deposit the view over the distance F of the gas supply plate 29 and a substrate 3 on the front face of a substrate 3 as film, either.
[0056] In the above 1 operation gestalt and the 2nd operation gestalt, although the silicon oxide film formation using a mono silane and oxygen was mentioned as the example and this invention was explained, liquid Si raw materials, such as high order silanes, such as a disilane, and TEOS (Tetraethoxysilane), etc. are sufficient instead of a mono silane, and nitrous oxide, nitrogen oxide, etc. may be used instead of oxygen.
[0057] Moreover, although explained by the remote plasma-CVD equipment in 1 operation gestalt and the 2nd

operation gestalt which were mentioned above mentioning oxidation silicone film formation as an example Even if it uses the silicon nitride film formation by the reaction of a mono silane and ammonia etc. for the plasma-CVD membrane formation accompanied by the gaseous-phase chemical reaction of other ingredient systems, the same effectiveness as the film generated with 1 operation gestalt and the 2nd operation gestalt can be acquired to the generated film.

[0058] Furthermore, although the example using parallel monotonous remote plasma-CVD equipment was given in the gestalt of the above operation, this invention will be applied, even if it is equipments of what kind of gestalt, such as plasma-CVD equipment using the microwave plasma, the electron cyclotron resonance plasma, inductively coupled plasma, and the helicon wave plasma, if it is plasma-CVD equipment with which two or more holes were prepared between the plasma production field and the substrate processing field R and which has a plasma confinement electrode for plasma separation.

[0059]

[Effect of the Invention] According to the remote plasma-CVD equipment of this invention, in the remote plasma CVD which forms membranes by the gaseous-phase chemical reaction, concentration of the inert gas which can control a superfluous advance of a gaseous-phase chemical reaction, and is injected out of a plasma field can be made into homogeneity on a deposited substrate. Therefore, according to the remote plasma-CVD equipment of this invention, in case gate dielectric film and the interlayer insulation film of a MOS device are produced, the precise film which does not contain particle etc. can be formed in a large area substrate at homogeneity.

[Translation done.]

TECHNICAL FIELD

[Field of the Invention] This invention relates to the formation approach of the film precise to the remote plasma-CVD equipment which separates a plasma production field and a substrate processing field especially, and the large area homogeneity by remote plasma CVD about the plasma-CVD approach which used plasma-CVD equipment and this.

[Translation done.]

PRIOR ART

[Description of the Prior Art] There is remote plasma-CVD equipment which divides a plasma production field and the substrate processing field R into one of the plasma-CVD equipment which performs film formation to a substrate controlling a plasma damage. Formation of the CVD film using this remote plasma equipment serves as a very important technique as a treatment process of thin film creation for producing a high-reliability device and a high performance device in a semiconductor device process.
[0003] As remote plasma-CVD equipment which can respond to large-sized substrates, such as a switching transistor formation process of a large area flat-panel display, a drive circuit transistor formation process, and a diameter silicon wafer process of macrostomia, parallel monotonous remote plasma-CVD equipment which is indicated by JP,5-21393,A, for example is indicated.
[0004] As the parallel monotonous mold remote plasma-CVD equipment in the remote plasma-CVD equipment of this conventional example is shown in drawing 7 , the plasma confinement electrode 8 using the mesh plate which two or more holes opened is formed between the counterelectrodes 2 and the RF impression electrodes 1 with which a substrate 3 is installed in conventional parallel monotonous plasma-CVD equipment. And parallel monotonous mold remote plasma-CVD equipment shuts up the plasma 6 between this plasma confinement electrode 8 and the RF impression electrode 1. the large area shut up between the plasma confinement electrode 8 and the RF impression electrode 1 parallel being monotonous -- substrate right above side internal division cloth, such as the neutral radical 4 supplied to the substrate processing field R from the uniform plasma 6 in order to supply gas, such as the neutral radical 4, to the substrate processing field R, -- a large area -- it becomes uniform and has the features that the thin film formation processing in a substrate 3 can carry out to homogeneity also to a large area substrate.
[0005] furthermore, generation processing of the film of on the process the inert gas nozzle 9 which injects inert gas 10 is formed near the hole 5 of a mesh plate, i.e., the passage hole of a radical 4, in the above-mentioned conventional example, and using the gaseous phase reaction of a radical 4 and inert gas 10, and as opposed to a substrate 3 -- setting -- a large area -- uniform processing is possible.
[0006] namely, when the parallel monotonous remote plasma-CVD equipment shown in drawing 7 performs membrane formation (generation processing of a thin film) accompanied by a gaseous-phase chemical reaction in the substrate processing field R The plasma (plasma 6) of the 1st gas which contributes to a reaction is formed. The radical passage hole 5 of the plasma confinement electrode 8 from this plasma Through, It is made to react with the 2nd gas which supplies the radical (radical 4) of the 1st excited gas, and the 1st gas which is not excited to the substrate processing field R, and is supplied from the inert gas nozzle 9, and a membrane formation precursor required for thin film generation is formed.
[0007] For example, in performing silicon oxide membrane formation by the reaction of a mono silane (SiH_4) and oxygen (O_2), make the 1st gas into oxygen and let the 2nd gas be a mono silane. Since opening of many radical passage holes 5 and inert gas nozzles 9 is carried out to the plasma confinement electrode 8 at this time, if the 2nd gas (inert gas 10) is supplied to homogeneity from many inert gas nozzles 9, the above-mentioned gaseous phase reaction in the substrate processing field R occurs in homogeneity in the right above side of a substrate 3, and can form the uniform film in the front face of a substrate 3.
[0008] Since it has mentioned above, promising ** of the parallel monotonous mold remote plasma-CVD equipment is carried out as an approach of forming the silicon oxide (SiO_2) film used as the gate dielectric film of a thin film transistor, a silicon nitride film (Si_3N_4 or Si_xN_y), the amorphous silicone film that similarly serves as a barrier layer of a thin film transistor, and a gate electrode on a large-sized glass substrate, the oxidation silicone film which serves as an interlayer insulation film of a transistor component on a large-sized Si substrate

further, a silicon nitride film, etc. on a large-sized glass substrate.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention] According to the remote plasma-CVD equipment of this invention, in the remote plasma CVD which forms membranes by the gaseous-phase chemical reaction, concentration of the inert gas which can control a superfluous advance of a gaseous-phase chemical reaction, and is injected out of a plasma field can be made into homogeneity on a deposited substrate. Therefore, according to the remote plasma-CVD equipment of this invention, in case gate dielectric film and the interlayer insulation film of a MOS device are produced, the precise film which does not contain particle etc. can be formed in a large area substrate at homogeneity.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] When the inert gas nozzle 9 tends to be formed near the radical passage hole 5 as mentioned above, and it is going to supply uniform inert gas 10 in a field from the inert gas nozzle 9, the plasma confinement electrode 8 of hollow structure will be used as indicated by the conventional example (JP,5-21393,A) mentioned above. In the plasma confinement electrode 8 of this hollow structure, as drawing 8 shuts up, an electrode side elevation and drawing 9 shut up and it is shown in an electrode plan, the radical passage hole 5 and the inert gas passage hole 9 are formed independently (dissociating) respectively, a radical 4 and inert gas 10 are mixed in a hollow field, and a radical 4 and inert gas 10 do not react in a hollow field.
[0010] As shown in drawing 9 or drawing 10 , as an approach of supplying inert gas 10, the approach of supplying inert gas 10 in the hollow field of the plasma confinement electrode 8 from the inert gas installation tubing 12 formed in plasma confinement electrode 8 lateral portion is indicated by the plasma confinement electrode 8 of hollow structure in the conventional example here from the vacuum chamber exterior.
[0011] By the approach of this conventional example, the pressures in the centrum in the plasma confinement electrode 8 are the membrane formation pressure of the substrate processing field R, and comparable, i.e., dozens mTorr(s) - hundreds mTorr(s), and low voltage. for this reason, as typically shown in the conceptual diagram of drawing 11 , a great portion of inert gas 10 will be injected from the inert gas nozzle 9 near the connection of the inert gas installation tubing 12 and the plasma confinement electrode 8, and only little inert gas 10 is injected from the nozzle 9 far from the inert gas installation tubing 12 -- having -- ** -- it is ** and the fault that injection of uniform inert gas 10 will be difficult in a field is shown in the front face of a substrate 3.
[0012] Thus, what is necessary is just to lengthen distance D of the plasma confinement electrode 8 and substrate 3 which inject inert gas 10, in order for injection of uniform inert gas 10 to form the uniform film in substrate 3 front face in a field in a difficult situation in the field to a front face. That is, if the 2nd gas (inert gas 10) is supplied to the substrate processing field R at the ununiformity within a field and the 1st gas and gaseous-phase chemical reaction are caused, in the neighborhood to which the 2nd gas was supplied, the substrate 3 right above side internal division cloth of the resultant (membrane formation precursor) generated as a result of the gaseous-phase chemical reaction will also serve as an ununiformity.
[0013] However, since the time amount diffused in the parallel direction to substrate 3 front face will be enough given while the 2nd gas and resultant move even a substrate 3 if the above-mentioned distance D excels, when arriving at substrate 3 front face, the field internal division cloth in substrate 3 front face equalizes. In this membrane formation approach, to the width of face W of a CVD chamber, if the distance D of the plasma confinement electrode 8 and a substrate 3 is large, it will become easy to acquire an equalization operation.
[0014] For example, in forming membranes to a 500mmx600mm glass substrate, the width of face W of a CVD chamber is set to about 800mm, and if distance D13 of a plasma confinement electrode and a substrate is set to about 800mm of the same die length, an equalization operation will fully appear. However, it sets to membrane formation by the gaseous-phase chemical reaction. The plasma confinement electrode 8 with which the nozzle 9 which injects inert gas 10 as mentioned above was formed, If distance D with a deposited substrate (substrate 3) is lengthened, the gaseous phase reaction of the 1st gas and the 2nd gas containing a neutral radical will progress superfluously, and in the gaseous phase in the substrate processing field R the film generated since grain (membrane formation precursor) growth progressed and this grown-up grain accumulated on a deposited substrate front face -- a non-dense -- the problem of being easy to become dense arises.
[0015] For example, when performing silicon oxide membrane formation by the gaseous-phase chemical reaction

of a mono silane and oxygen, a particle-like SiOx grain (membrane formation precursor) will grow in the gaseous phase in the substrate processing field R. the non-dense generated as mentioned above — since defect density is high, it is large and leakage current becomes low also in withstand voltage, the dense film cannot be used for the gate dielectric film of a thin film transistor etc.

[0016] This invention is to have been made under such a background and offer the remote plasma-CVD equipment and the remote plasma-CVD forming-membranes method for it being precise on a deposited substrate and being able to perform uniform film deposition in a field, without causing the grain growth by the superfluous gaseous-phase chemical reaction, which can supply a membrane formation precursor in membrane formation by the remote plasma-CVD approach by the gaseous-phase chemical reaction.

[Translation done.]

MEANS

[Means for Solving the Problem] It is characterized by to form the gaseous-diffusion plate for this invention being 1500 or less times of mean free path lambdag at the time of membrane formation [in / in the distance of the perpendicular direction of the plasma confinement electrode plate with which the introductory hole which introduces the 2nd gas into a substrate processing field has been arranged, and a deposited substrate / a substrate processing field], in order to attain the above-mentioned purpose, and said plasma-confinement electrode plate being hollow structure, and equalizing the 2nd gas within a plate. Since the 2nd gas is equalized within a plasma confinement electrode plate with a diffusion plate and it is introduced into a substrate processing field, The count of a chemical reaction is restricted. various base which the uniform gaseous-phase chemical reaction in a substrate right above side occurs, and happens after the 2nd gas is introduced into a substrate processing field before reaching a substrate -- Since the grain growth by the gaseous phase by overresponse is controlled by satisfactory level, the uniform and precise film can be formed in a field on a deposited substrate. Moreover, the distance of the perpendicular direction of the gas supply plate which the introductory hole which introduces the 2nd gas into a substrate processing field is arranged in this invention, and is located between a plasma confinement electrode and a deposited substrate, and a deposited substrate It is characterized by forming the gaseous diffusion plate for being 1500 or less times of mean free path lambdag at the time of the membrane formation in a substrate processing field, and said gas supply plate being hollow structure, and equalizing the 2nd gas within a plate. Since the 2nd gas is equalized within a gas supply plate with a diffusion plate and it is introduced into a substrate processing field, The count of a chemical reaction is restricted. various base which the uniform gaseous-phase chemical reaction in a substrate right above side occurs, and happens after the 2nd gas is introduced into a substrate processing field before reaching a substrate -- Since the grain growth by the gaseous phase by overresponse is controlled by satisfactory level, the uniform and precise film can be formed in a field on a deposited substrate.
[0018] The substrate processing field in which, as for invention according to claim 1, a deposited substrate is installed in plasma-CVD equipment, Separate the plasma production field which forms the plasma of the 1st gas, and said substrate processing field and plasma production field, and the plasma of said 1st gas is shut up. It is plasma-CVD equipment which has the plasma confinement electrode plate with which the hole which passes the 1st gas which contains a neutral radical from said plasma of the 1st gas has been arranged. Said plasma confinement electrode plate is hollow structure, and the gaseous diffusion plate for equalizing the 2nd gas within this plasma confinement electrode plate is formed in the interior. The 2nd gas which forms the desired film in said deposited substrate by the gaseous-phase chemical reaction with said neutral radical The introductory hole introduced into said substrate processing field is arranged at said plasma confinement electrode plate, and it is characterized by the distance of the perpendicular direction of said plasma confinement electrode plate and said deposited substrate being 1500 or less times of mean free path lambdag at the time of the membrane formation in a substrate processing field.
[0019] Invention according to claim 2 is characterized by said gaseous diffusion plates being two or more diffusion plates mutually located in parallel within a plasma confinement electrode in plasma-CVD equipment according to claim 1.
[0020] The 1st process in which invention according to claim 3 forms the plasma of the 1st gas in a plasma production field in the plasma-CVD membrane formation approach, The 2nd process which shuts up said plasma with a plasma confinement electrode plate in said plasma production field, The 3rd process in which the 1st gas by which a plasma confinement electrode plate lets the arranged hole pass, and contains a neutral radical from said plasma is passed to a substrate processing field, Said plasma confinement electrode plate with the gaseous

diffusion plate which was formed in the interior and which equalizes the 2nd gas By the gaseous-phase chemical reaction of the 4th process which supplies the 2nd gas equalized to the substrate processing field in which a deposited substrate is installed, the 1st gas containing said neutral radical, and said 2nd gas It has the 5th process which forms the desired film in a deposited substrate, and is characterized by the distance of a perpendicular direction with a deposited substrate being 1500 or less times of mean free path lambdag at the time of the membrane formation in a substrate processing field a plasma confinement electrode plate and said first half.

[0021] The substrate processing field in which, as for invention according to claim 4, a deposited substrate is installed in plasma-CVD equipment, Separate the plasma production field which forms the plasma of the 1st gas, and said substrate processing field and plasma production field, and the plasma of said 1st gas is shut up. By the gaseous-phase chemical reaction with the 1st gas which is plasma-CVD equipment which has the plasma confinement electrode plate with which the hole which passes the 1st gas which contains a neutral radical from said plasma of the 1st gas has been arranged, and contains said neutral radical It has the gas supply plate with which two or more introductory holes which introduce into a substrate processing field the 2nd gas which forms the desired film in said deposited substrate were prepared between said plasma confinement electrode plate and said deposited substrate. It is characterized by being hollow structure, forming the gaseous diffusion plate for equalizing the 2nd gas within a plate in the interior, and said gas supply plate having become 1500 or less times of mean free path lambdag at the time of membrane formation [in / in the distance of the perpendicular direction of said gas supply plate and a deposited substrate / a substrate processing field].

[0022] Invention according to claim 5 is characterized by said gaseous diffusion plates being two or more diffusion plates located in parallel mutually in gas supply Sakauchi in plasma-CVD equipment according to claim 4.

[0023] The 1st process in which invention according to claim 6 forms the plasma of the 1st gas in a plasma production field in the plasma-CVD membrane formation approach, The 2nd process which shuts up said plasma with a plasma confinement electrode plate in said plasma production field, The 3rd process which supplies the 1st gas by which a plasma confinement electrode plate lets the arranged hole pass, and contains a neutral radical from said plasma between this plasma confinement electrode plate and a gas supply plate, The 4th process in which the 1st gas by which said gas supply plate contains a neutral radical from two or more arranged introductory holes is passed to a substrate processing field, and said gas supply plate with the gaseous diffusion plate which was formed in the interior and which equalizes the 2nd gas By the gaseous-phase chemical reaction of the 5th process which supplies the 2nd gas equalized to the substrate processing field in which a deposited substrate is installed, the 1st gas containing said neutral radical, and said 2nd gas It has the 6th process which forms the desired film in a deposited substrate, and is characterized by the distance of the perpendicular direction of said gas supply plate and said deposited substrate being 1500 or less times of mean free path lambdag at the time of the membrane formation in a substrate processing field.

[0024]

[Embodiment of the Invention] Hereafter, the operation gestalt of this invention is explained with reference to a drawing. Drawing 1 is the conceptual diagram showing the cross section of the configuration of the remote plasma-CVD (chemical vapor growth) equipment by 1 operation gestalt of this invention. Oxidation silicone film formation [in / for 1 operation gestalt of this invention / the parallel monotonous remote plasma-CVD equipment of oxygen / silane system] is taken for an example, and it explains with reference to drawing below at a detail. About the same configuration as the conventional example, the same sign is attached and explanation of this configuration is omitted.

[0025] In this drawing parallel monotonous remote plasma-CVD equipment As fundamentally shown in drawing 1 , the radical passage hole 5 and the inert gas nozzle 5 which pass the vacuum chamber in which evacuation is possible, RF generator 13, the high frequency impression electrode 1, the counterelectrode 2 that supports a substrate 3, and the gas containing a neutral radical (installation) are prepared. And it is constituted by the inert gas installation tubing 12 which is equipped with the plasma confinement electrode 20 grounded electrically, and introduces inert gas (for example, mono silane 19) from the side face of the plasma confinement electrode 20.

[0026] Moreover, the diffusion plate which has a radical passage hole and an inert gas nozzle prepares in the interior at the plasma confinement electrode 20, and it is ********. The cross-section schematic diagram of the plasma confinement electrode 20 which has this diffusion plate is shown in drawing 2 . In this drawing, the 1st gaseous diffusion plate 23 and the 2nd gaseous diffusion plate 24 are formed, and are in the centrum inserted into the plasma confinement electrode up plate 26 and the plasma confinement electrode lower plate 27

(arranged)., two or more gaseous diffusion plates, i.e., 1 operation gestalt, for diffusing mono-silane gas (inert gas) 19 in homogeneity

[0027] In drawing 2 , mono-silane gas 19 is supplied between the plasma confinement electrode up plate 26 and the 1st gaseous diffusion plate 23. Mono-silane gas 19 is equalized by hole 9A of the 1st gaseous diffusion plate 23. Furthermore it is equalized by hole 9B of the 2nd gaseous diffusion plate 24, and mono-silane gas 19 is injected toward a substrate 3 by the homogeneity within a field from the inert gas nozzle 9 finally prepared in the plasma confinement electrode lower plate 27.

[0028] Here, it dissociates (becoming independent) and hole 9A, hole 9B and the inert gas nozzle 9, and the radical passage hole 5 are respectively formed in the plasma confinement electrode 20 so that an oxygen radical and the oxygen molecule 21, and mono-silane gas 19 may not be mixed. In order to perform the above-mentioned separation, the radical passage hole 5 is a connected hole which was formed with the wall isolated from the field where a mono silane exists, and has penetrated between the plasma confinement electrode up plate 26 and the plasma confinement electrode lower plates 27. In addition, although drawing 2 shows two diffusion plates of the 1st diffusion plate 23 and the 2nd diffusion plate 24, one sheet, two or more two sheets or more, or how many sheets are sufficient as this diffusion plate.

[0029] The opening aperture of the radical passage hole 5 penetrated between the plasma confinement electrode up plate 26 and the plasma confinement electrode lower plate 27 is set as the die length of 2 double less or equal extent of the Debye length of the plasma in the generated oxygen plasma 22 so that the generated oxygen plasma 22 can be shut up efficiently.

[0030] Next, drawing 3 shows the top view of the plasma confinement electrode up plate 26 and the plasma confinement electrode lower plate 27. Drawing 3 (a) shows the top view of the plasma confinement electrode up plate 26, and drawing 3 (b) shows the top view of the plasma confinement electrode lower plate 27.

[0031] Here, in drawing 3 (a), the radical passage hole 5 which passes the gas containing a neutral radical is punctured by predetermined spacing within the plate at homogeneity from the oxygen plasma 22 shut up by the plasma confinement electrode up plate 26. Moreover, in drawing 3 (b), from the oxygen plasma 22 shut up by the plasma confinement electrode lower plate 27, the radical passage hole 5 which passes the gas containing a neutral radical is punctured by predetermined spacing at the homogeneity in a plate, and the inert gas nozzle 9 is punctured by predetermined spacing in the location which is not in agreement with this radical passage hole 5 at the homogeneity in a plate.

[0032] Next, drawing 4 shows the top view of a gaseous diffusion plate (the 1st gaseous diffusion plate 23 and 2nd gaseous diffusion plate 24). Here, two above-mentioned gaseous diffusion plates, the 1st gaseous diffusion plate 23, and the 2nd gaseous diffusion plate 24 are equivalent to the 1st gaseous diffusion plate 23 of drawing 2 , and the 2nd gaseous diffusion plate 24.

[0033] In drawing 4 (a), the radical passage hole 5 which passes the gas which contains a neutral radical in the 1st gaseous diffusion plate 23 is punctured by predetermined spacing within a plate at homogeneity, and the inert gas passage hole 9 is punctured by homogeneity in the location which is not in agreement with the radical passage hole 5 of the predetermined field Q near a core. Moreover, in drawing 4 (b), the radical passage hole 5 which passes the gas which contains a neutral radical in the 2nd gaseous diffusion plate 24 is punctured by predetermined spacing within a plate at homogeneity, and the inert gas passage hole 9 is punctured by homogeneity in the location which is not in agreement with the radical passage hole 5 of the predetermined field P near a core.

[0034] Here, Field P shows a field larger than Field Q in plane view, including the above-mentioned field Q, when installing the 1st gaseous diffusion plate 23 and the 2nd gaseous diffusion plate 24 in the plasma confinement electrode 20 and these two diffusion plates are piled up. That is, the inert gas passage hole 9 is not only punctured by the puncturing location in the 1st gaseous diffusion plate 23, and the same location, but in the 2nd gaseous diffusion plate 24, the inert gas passage hole 9 is further punctured by the periphery field.

[0035] On the whole surface in a diffusion plate, although opening of the hole of inert gas passage may be carried out to homogeneity, as mentioned above By devising the location of the hole of the diffusion plate which plurality piles up as shown in drawing 4 As shown in drawing 11 , it can prevent a lot of gas being injected by the substrate processing field R in the inert gas installation tubing 12 neighborhood, and uniform inert gas (for example, mono-silane gas 19 grade) can be supplied more in a field to the front face of a substrate 3.

[0036] moreover, in the configuration of a diffusion plate, when installing the 1st gaseous diffusion plate 23 and the 2nd gaseous diffusion plate 24 in the plasma confinement electrode 20 and these two diffusion plates are piled up, the configuration which forms the mono-silane gas (inert gas) 19 of two or more diffusion plates so that

the hole to pour, i.e., hole 9A, and hole 9B may not lap in plane view (it is not located on a straight line — as) is also possible.
[0037] Next, with reference to drawing 1 , drawing 2 , drawing 3 , and drawing 4 , the formation approach of the oxidation silicone film to substrate 3 front face by the remote plasma-CVD equipment by 1 operation gestalt of this invention is explained below. Within the CVD chamber in an evacuation condition (it has a predetermined pressure) Introduce oxygen gas 18 into the RF impression electrode 1, and this oxygen gas 18 is supplied in the direction of the plasma confinement electrode 20 from the inferior surface of tongue of the RF impression electrode 1 at homogeneity. Glow discharge is made to start from RF generator 13 by the RF supplied to the RF impression electrode 1 between the plasma confinement electrodes 20 which have a diffusion plate (the 1st gaseous diffusion plate 23 and the 2nd diffusion plate 24 which are shown in drawing 4).
[0038] The oxygen plasma 22 generated by this glow discharge is efficiently shut up between the RF impression electrode 1 and the plasma confinement electrode 20. The plasma consistency between the plasma confinement electrode 20 and a counterelectrode 2 (or substrate 3) has become about [105cm - 3-106cm -] three to the plasma consistency in the result 22, for example, the oxygen plasma, being about [1010cm -] three.
[0039] That is, although an electron, oxygen atom ion, oxygen molecular ion, an oxygen atom radical, an oxygen molecule radical, and an oxygen molecule exist in the oxygen plasma 22, it is shown that the electron and ion which invade out of the plasma are the amount of extent which can be disregarded. Therefore, what it reacts with the mono-silane gas 19 injected by the substrate processing field R besides the oxygen plasma 22, and is contributed to silicon oxide film membrane formation is an oxygen atom radical, an oxygen molecule radical, and an oxygen molecule that is not excited.
[0040] And an oxygen radical and the oxygen molecule 21 are diffused to the substrate processing field R through the radical passage hole 5, and the mono-silane gas 19 and the gaseous-phase chemical reaction which were injected from the inert gas nozzle 9 are caused. Of this gaseous-phase chemical reaction, silicon oxide precursors (membrane formation precursor), such as SiOx, SiOxHy, and SiHy, are formed, and when this formed silicon oxide precursor accumulates on substrate 3 front face, an oxidation silicone film is formed in substrate 3 front face.
[0041] The distance D of the plasma confinement electrode 20 and a substrate 3 (vertical distance) is set up here so that it may become 1500 or less (however, number exceeding "0") times of average free process lambdag of the oxygen (the oxygen radical and oxygen molecule 21) / mono-silane mixed gas in the substrate processing field R. Since it has controlled that a gaseous-phase chemical reaction progresses superfluously with this distance D, when oxidation silicone film precursors, such as SiOx, SiOxHy, and SiHy, carry out grain growth by the gaseous phase in the substrate processing field R, it does not grow up to be particle-like magnitude.
[0042] For example, what is necessary is just to set distance D of a plasma confinement electrode and a substrate to 90mm or less in the gas temperature of 300 degrees C, and chamber pressure 250mTorr, since average free process lambdag of oxygen / mono-silane mixed gas is about 60 micrometers. The leak current characteristic when using as the gate dielectric film of an MOS (metal, oxide-film, and semi-conductor) capacitor the oxidation silicone film which actually formed membranes as an example which formed the oxidation silicone film on condition that the substrate temperature of 300 degrees C, substrate processing field R pressure 250mTorr, oxygen flow rate 800sccm supplied to a plasma field through the RF impression electrode 1, and mono-silane quantity-of-gas-flow 5sccm supplied to the inert gas installation tubing 12 is shown in drawing 5 .
[0043] In drawing 5 , the leak current density value has changed a lot by the case where distance D of the plasma confinement electrode 20 and a substrate 3 is set to 300mm, and the case where it is made 60mm. That is, the leak current characteristic of the film which formed the distance D of the plasma confinement electrode 20 and a substrate 3 as 60mm has near, the electric insulating property [it is good and] which can be used as gate dielectric film and the interlayer insulation film of a thin film transistor, and pressure-proofing in the current characteristic of the silicon thermal oxidation film.
[0044] On the other hand, big leakage current is flowing from the low electric-field field, the leak current characteristic of the film which formed the distance D of the plasma confinement electrode 20 and a substrate 3 as 300mm has an electric insulating property and low pressure-proofing to gate dielectric film and the interlayer insulation film of a thin film transistor, and they cannot use it for them.
[0045] In the experiment conditions mentioned above, average free process lambdag of the oxygen / mono-silane mixed gas in the substrate processing field R is about 60 micrometers. At this time, it corresponds by about 5000 times the above-mentioned average free process lambdag the distance D of an electric insulating property and the plasma confinement electrode 20 with lower pressure-proofing, and a substrate 3, i.e., 300mm.

[0046] On the other hand, it corresponds by about 1000 times the above-mentioned average free process lambdag the distance D of an electric insulating property and the plasma confinement electrode 20 with lower pressure-proofing, and a substrate 3, i.e., 60mm. If the distance D of the plasma confinement electrode 20 and a substrate 3 is 5000 times as large as the above-mentioned average free process lambdag, the gaseous-phase chemical reaction of an oxygen radical and the oxygen molecule 21, and mono-silane gas 19 will progress too much, the particle which carried out grain growth in the gaseous phase in the substrate processing field R will accumulate on substrate 3 front face as film, and it will be guessed that the roughness and fineness film has been formed in substrate 3 front face.
[0047] On the other hand, if it is the distance D of the about 1000 times [of the above-mentioned average free process lambdag] plasma confinement electrode 20, and a substrate 3, the gaseous-phase chemical reaction of an oxygen radical and the oxygen molecule 21, and mono-silane gas 19 will not progress too much, grain growth in a gaseous phase will be restricted, and it will be guessed that a particle-like oxidation silicone film precursor does not accumulate as film in substrate 3 front face.
[0048] Moreover, as mentioned above, since the plasma consistency between the plasma confinement electrode 20 and a counterelectrode 2 is very low, compared with the usual parallel monotonous plasma CVD, the plasma damage to a substrate 3 is stopped very low.
[0049] To the case on the front face of silicon in which the front face of a substrate 3 forms an MOS interface, this effectiveness When it appears notably and SiO2 film is formed on a single crystal silicon substrate by the usual parallel monotonous plasma CVD When an oxidation silicone film is formed by parallel monotonous remote plasma CVD to the MOS interface-state-density consistency being 1011-1012cm-2eV-1 near a mid gap, it becomes an about [-1010cm-2eV-1] low interface-state-density consistency.
[0050] As mentioned above, although 1 operation gestalt of this invention has been explained in full detail with reference to a drawing, a concrete configuration is not restricted to this operation gestalt, and even if the design change of the range which does not deviate from the summary of this invention etc. occurs, it is included in this invention. For example, the parallel monotonous remote plasma CVD by the 2nd operation gestalt is explained using drawing 6 . Drawing 6 is the conceptual diagram showing the cross section of the configuration of parallel monotonous mold remote plasma-CVD equipment. About the same configuration as the conventional example and 1 operation gestalt, the same sign is attached and explanation of this configuration is omitted.
[0051] In this drawing, the parallel monotonous mold remote plasma-CVD equipment of drawing 6 differing from the parallel monotonous remote plasma-CVD equipment of drawing 1 is that the gas supply plate 29 which the inert gas installation tubing 12 is connected, introduces inert gas (mono-silane gas 19) into it, equalizes gas concentration with the gaseous diffusion plate formed in the interior, and is injected to a substrate side does not have the function of plasma confinement.
[0052] For this reason, that aperture is arbitrary if homogeneity injection of a radical 4 is possible for the radical passage hole 5 of the gas supply plate 29 which has a diffusion plate. Moreover, it is also possible to use it in the state of electric suspension, without grounding electrically. That is, although the gas supply plate 29 of the configuration itself is the same as that of the plasma confinement electrode 20 in 1 operation gestalt, the apertures of the point and radical passage hole which are not grounded differ.
[0053] In addition, this gas supply plate 29 is located between the plasma confinement electrode 8 and a counterelectrode 2, and it is set up so that the distance F of the gas supply plate 29 and a substrate 3 may become 1500 or less (however, number exceeding "0") times of average free process lambdag of the oxygen (the oxygen radical and oxygen molecule 21) / mono-silane mixed gas in the substrate processing field R.
[0054] Except the above, it has the structure where the plasma confinement electrode 20 which has the gas supply plate 29 which has a diffusion plate in the 2nd operation gestalt, and a diffusion plate in 1 operation gestalt is the same. Moreover, the view about the relation of distribution of the hole which passes the radical passage hole and inert gas in the structure of the gaseous diffusion plate in the gas supply plate 29 and the number of gaseous diffusion plates, and a gaseous diffusion plate etc. is the same as that of the gaseous diffusion plate (the 1st gaseous diffusion plate and 2nd gaseous diffusion plate) formed in the plasma confinement electrode 20 in 1 operation gestalt.
[0055] Moreover, it is the same as that of the view about the distance D of the plasma confinement electrode 20 and substrate 3 in 1 operation gestalt, an oxygen radical and the oxygen molecule 21, and the gaseous-phase chemical reaction of mono-silane gas 19 do not progress too much, grain growth in a gaseous phase is restricted, and particle does not deposit the view over the distance F of the gas supply plate 29 and a substrate 3 on the front face of a substrate 3 as film, either.

[0056] In the above 1 operation gestalt and the 2nd operation gestalt, although the silicon oxide film formation using a mono silane and oxygen was mentioned as the example and this invention was explained, liquid Si raw materials, such as high order silanes, such as a disilane, and TEOS (Tetraethoxysilane), etc. are sufficient instead of a mono silane, and nitrous oxide, nitrogen oxide, etc. may be used instead of oxygen.
[0057] Moreover, although explained by the remote plasma-CVD equipment in 1 operation gestalt and the 2nd operation gestalt which were mentioned above mentioning oxidation silicone film formation as an example Even if it uses the silicon nitride film formation by the reaction of a mono silane and ammonia etc. for the plasma-CVD membrane formation accompanied by the gaseous-phase chemical reaction of other ingredient systems, the same effectiveness as the film generated with 1 operation gestalt and the 2nd operation gestalt can be acquired to the generated film.
[0058] Furthermore, although the example using parallel monotonous remote plasma-CVD equipment was given in the gestalt of the above operation, this invention will be applied, even if it is equipments of what kind of gestalt, such as plasma-CVD equipment using the microwave plasma, the electron cyclotron resonance plasma, inductively coupled plasma, and the helicon wave plasma, if it is plasma-CVD equipment with which two or more holes were prepared between the plasma production field and the substrate processing field R and which has a plasma confinement electrode for plasma separation.

[Translation done.]

DESCRIPTION OF DRAWINGS

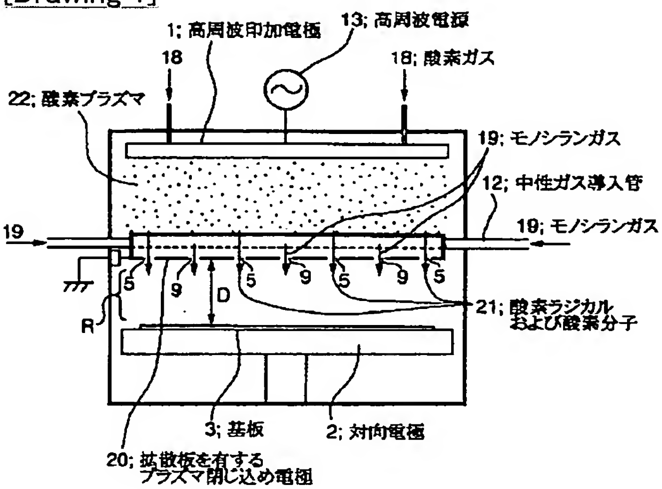
[Brief Description of the Drawings]
[Drawing 1] It is the side-face schematic diagram of the parallel monotonous remote plasma-CVD equipment in the gestalt of operation of the 1st of this invention.
[Drawing 2] It is the cross-section schematic diagram of an electrode in the slight plasma closing depth in the 1st operation gestalt of this invention which has a diffusion plate.
[Drawing 3] It is the flat-surface schematic diagram of the up plate of an electrode, and a lower plate in the slight plasma closing depth in the gestalt of operation of the 1st of this invention which has a diffusion plate.
[Drawing 4] It is the flat-surface schematic diagram of the diffusion plate in the gestalt of operation of the 1st of this invention.
[Drawing 5] It is drawing having shown the leak current characteristic of the deposited oxidation silicone film.
[Drawing 6] It is the side-face schematic diagram of the parallel monotonous remote plasma-CVD equipment in the gestalt of operation of the 2nd of this invention.
[Drawing 7] It is the side-face schematic diagram of the parallel monotonous remote plasma-CVD equipment in the conventional example.
[Drawing 8] It is the cross-section schematic diagram of the plasma confinement electrode of the hollow structure in the conventional example.
[Drawing 9] It is the flat-surface schematic diagram of the plasma confinement electrode of the hollow structure in the conventional example.
[Drawing 10] In the conventional example, it is the side-face schematic diagram of the parallel monotonous remote plasma-CVD equipment which showed how to supply inert gas from the vacuum chamber exterior to the plasma confinement electrode of hollow structure.
[Drawing 11] In the plasma confinement electrode of the hollow structure in the conventional example, it is the cross-section schematic diagram of the plasma confinement electrode in which the situation of injection of gas is shown.
[Description of Notations]
1 RF Impression Electrode
2 Counterelectrode
3 Substrate
4 Radical
5 Radical Passage Hole
6 Plasma
7 Chamber Wall
8 Plasma Confinement Electrode
9 Inert Gas Nozzle
10 Inert Gas
11 Inert Gas for Plasma Decomposition
12 Inert Gas Installation Tubing
13 RF Generator
16 Evacuation
18 Oxygen Gas
19 Mono-Silane Gas
20 Plasma Confinement Electrode Which Has Diffusion Plate (Plasma Confinement Electrode)

21 Oxygen Radical and Oxygen Molecule
22 Oxygen Plasma
23 1st Gaseous Diffusion Plate
24 2nd Gaseous Diffusion Plate
26 Plasma Confinement Electrode Up Plate
27 Plasma Confinement Electrode Lower Plate
29 Gas Supply Plate Which Has Diffusion Plate

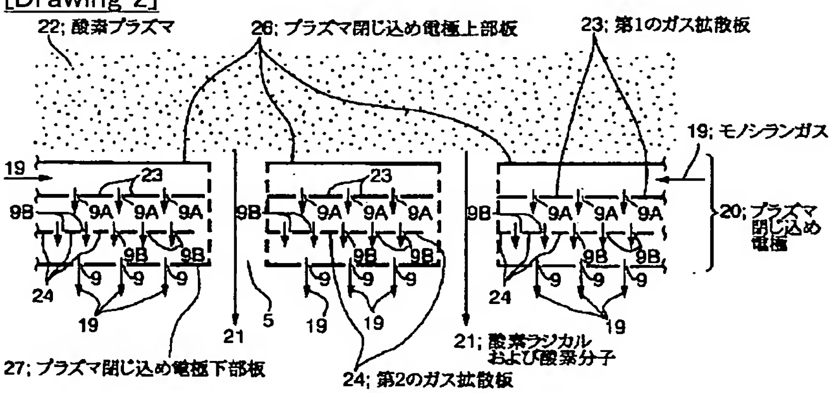
[Translation done.]

DRAWINGS

[Drawing 1]

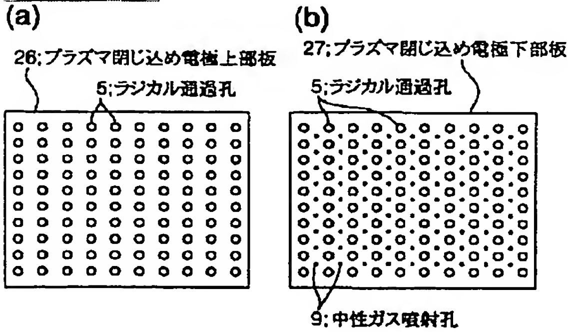


[Drawing 2]

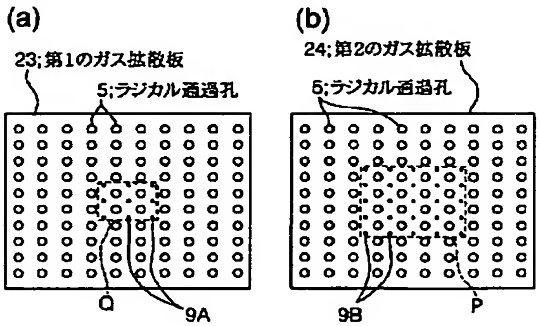


[Drawing 3]

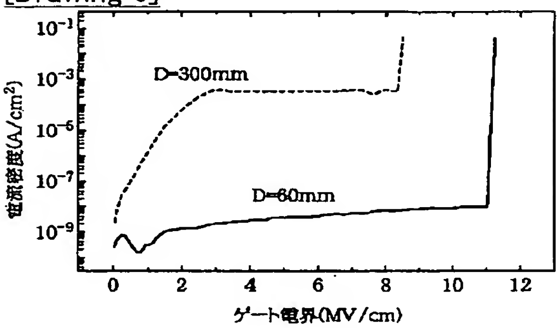
(a) (b)



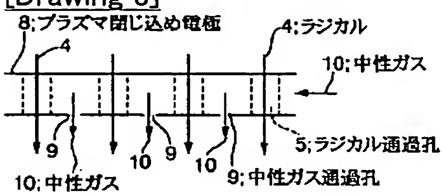
[Drawing 4]



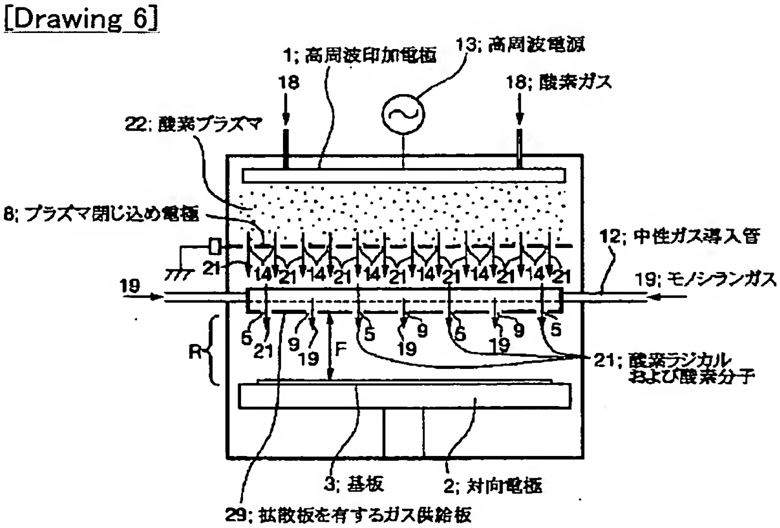
[Drawing 5]



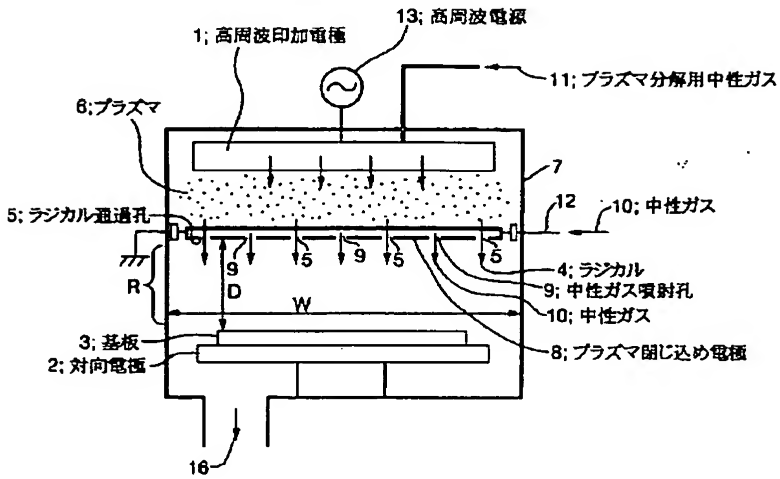
[Drawing 8]



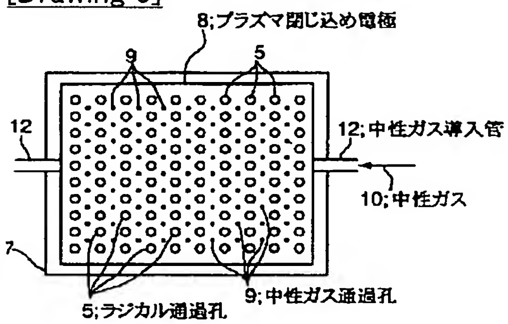
[Drawing 6]



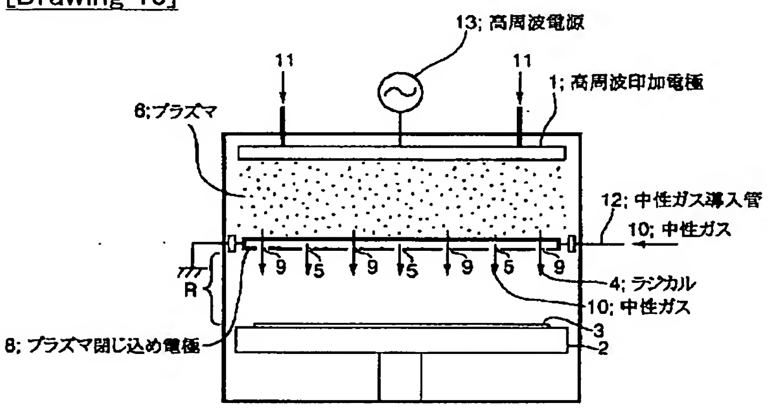
[Drawing 7]



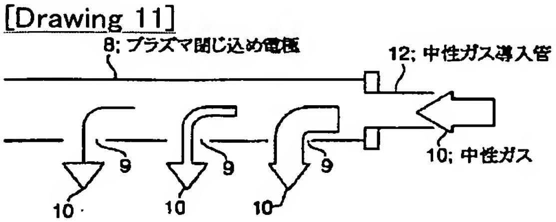
[Drawing 9]



[Drawing 10]



[Drawing 11]



[Translation done.]